PLEIADeS

Participatory multi-Level EO-assisted tools for Irrigation water management and Agricultural Decision-Support

Work Package 0: Project Management

Final Activity Report

covering the period from 15 September 2006 to 14 November 2009

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with contributions from

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Junta de Extremadura, Dirección General de Agricultura	Junta Ex [2])	Spain
Instituto de Agricultura Sostenible, CSIC Córdoba	CSIC	Spain
Ministério da Agricultura, Desenvolvimento Rural e das Pescas	MADRP[2])	Portugal
Associação de Beneficiários do Caia	AB Caia [1]) [2])	Portugal
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Contents

Acronyms

EO	Earth Observation
ET	Evapotranspiration
GIS	Geographical Information System
DSS	Decision-Support System
ICT	Information and Communication Technologies
MSP	Multi-stakeholder processes
NT	New Technologies (Earth observation, GIS, ICT, DSS)
NDVI	Normalized Difference Vegetation Index
SPIDER	System of Participatory Information, Decision support, and Expert knowledge for River-basin water management
WP	workpackage

Short term for pilot areas:

BR	Brazilian pilot area
ES	Spanish pilot area
GR	Greek
IT	Italian
MA	Moroccan
MX	Mexican
PE	Peruvian
PT	Portuguese
TR	Turkish
US	U.S.A. (additional pilot area brought in through non-budgeted partner USU)

1 Background and project objectives

Water is a critical resource worldwide and water conflicts are arising in many regions, with available resources diminishing in quantity and quality and the range of uses in competing sectors increasing. Water for food production represents by far the largest share among all uses and its demand keeps growing with increasing population and changing diets. Lack of water can adversely affect the economic and social stability of entire regions.

Saving water in irrigated agriculture can be achieved through the use of Earth observation (EO)-derived information in operational irrigation scheduling at farm and field scale. End-users of the information are the farmers, who experience benefits in the form of "more crops per drop" (enhanced water productivity) and "more jobs per drop" (boost of rural development). Space-assisted Irrigation Advisory Services at irrigation district level can provide the EO-derived irrigation scheduling information to them, interacting with water management decision makers at river basin level, and serving as a potential policy instrument at national scale.

The concept of irrigation modernization has evolved over the years from the mere introduction of new technical infrastructure and equipment towards a more holistic concept including measures to optimize water application. Such a system now includes also tools to generate information on most efficient water use and mechanisms to transmit this information to farmers.

New tools are needed to support this process. Current irrigation management systems are normally not able to cover each farm holding in extended areas at regular short time intervals. EO from satellite, in combination with Geographical Information Systems (GIS), is naturally destined to fill such a gap. In parallel, last-generation Information and Communication Technologies (ICT) open vast possibilities to transmit spatialized information to users and other stakeholders in a personalized way using internet and mobile phones.

PLEIADeS carries the concept of irrigation modernization one step farther. It defines the performance of irrigation schemes in a comprehensive sense that covers the economic, environmental, technical, social, and political dimensions. As such, it also links the scales from farm to irrigation scheme to river-basin. Leading-edge technologies and participatory approaches are working in synergy to achieve this goal.

PLEIADeS addresses the efficient and sustainable use of water for food production in water-scarce environments. It aimed to improve the performance of irrigation schemes by means of a range of measures that consider the economic, environmental, technical, social, and political dimensions through a synergy of leading-edge technologies and participatory approaches. Major social and technical innovation was made possible by the comprehensive space-time coverage of Earth observation (EO) data and the interactive networking/connecting capabilities of Information and Communication Technologies.

A set of nine pilot Case Studies represents a sample of the wide range of conditions found in the Mediterranean and in the Americas, covering Portugal, Spain, Italy, Greece, Turkey, Morocco, Mexico, Peru, and Brazil.

PLEIADeS was expected to generate new knowledge on the functioning and performance of these pilot areas. This in turn aimed at providing the knowledge and information base for decision makers at all levels on agricultural water needs and consumption. It also set out to provide the basis for assessing the benefits and threats potentially brought about by new technologies to all actors in changing environments. The project was also expected to generate new tools for irrigation water management, combining innovative sensor technology with flexible easy-to-use Decision-Support Systems for adaptive management. These tools were designed to help farmers to control water more efficiently and improve the environmental and economic performance of their irrigation systems.

2 Overview of project

The PLEIADeS approach

The project revolves around users (irrigation water managers and farmers) and other stakeholders. The first project phase was dedicated to assessing and analyzing their situation in each pilot area, covering technical data as well as the stakeholders' perceptions on current needs and future perspectives. Along with reports on stakeholder analysis and baseline descriptions of pilot areas a set of video Pilot Stories was created. Several of these Pilot Stories have been made available on www.youTube.es/pleiades8stories.

The technical development has been based on a joint vision of stakeholders (articulating their requirements) and system developers (proposing tailor-made technical solutions) and a continuous dialogue between them. The common goal has been to offer the information to a wide range of stakeholders at their required space-time resolution in non-academic, non-technical, easy-to-use and intuitive form that encourages participation. Working directly with key users and the relevant government organisations, including active stakeholder participation and gender mainstreaming, has indeed opened up many chances for successful implementation in policy and practice.

Technological innovation to support monitoring, management, and participative decision making

The technical innovation is based on the complementary use of mature Earth observation (EO) methodology in GIS-based web services with online analysis capability. These technologies provide easy access to information for all stakeholders while transparency and active participation are being enhanced by spatial information and innovative networking tools.

The **S**ystem for **P**articipatory **I**nformation, **D**ecision support, and **E**xpert knowledge for irrigation and **R**iver basin water management (SPIDER) is the central technical outcome of the project. Its technical core consists of an advanced web-based GIS tool and a novel package of operational EO methodology. The design of SPIDER was oriented towards its global application, including the capability to be configured and installed by the responsible partner in each pilot area.

For farmers and irrigation scheme water managers, SPIDER generates weekly or bi-weekly irrigation scheduling information products from a virtual constellation of high-resolution EO satellites and delivers them to farmers in near-real-time using leading-edge on-line analysis and visualization tools. It is supported by a methodology package to derive crop coefficients and further advanced parameters from EO satellite images in an operational processing chain. The satellite can "see" for example the actual crop vigor and water requirements (in combination with agrometeorological data) over extended areas and can detect inhomogeneities within individual fields.

For water managers at irrigation district and river-basin scale, SPIDER provides monitoring products, like maps of consumptive water use, with options to derive values aggregated over an irrigation season and/or over spatial water management units and/or crop types.

This technical core is supported by set of frameworks for performance and impact assessment, which has been designed to bring about measurable improvement of irrigation water management in a multi-efficiency context and to strengthen the participatory process. The set includes frameworks for irrigation performance assessment, environmental performance assessment, socio-economic assessment and cost-benefit analysis, for the assessment of impacts of climate- and policy-related external drivers, and for social multi-criteria evaluation.

In support of participatory processes, be they incipient or ongoing, SPIDER can first collect all available information and then provide this information from local to river-basin scale to all stakeholders involved and thus facilitate discussion, enhance transparency, and enable informed and shared decisions.

The development of SPIDER in each pilot area has been driven by the needs and perceptions of the users. At all project stages, it was a joint venture of the project team composed of selected key stakeholders, information service providers, and research groups. The general philosophy is that of an open-source system that is made available to users on a non-commercial licence basis. From the very beginning, the clear intention has been to implement an operational version in some pilot areas by the end of the project time. This has actually been achieved in several pilot areas, with details of this implementation depending on the local situation.

Participatory evaluation with stakeholders

The central hypothesis of PLEIADeS has been that a tool like SPIDER can make an essential contribution to changing irrigation water management at several levels. Social and technical learning are an important part of this process. We intended to initiate this process by means of pilot campaigns which were conducted in each pilot area. There, the core users (irrigation scheme managers, farmers, and river-basin authorities) were provided with SPIDER and its products and services during several months. The local project teams provided technical training at the beginning and support during the whole campaign. Group meetings were held to discuss their experiences, comparing the situation with or without SPIDER.

Furthermore, a set of frameworks for performance and impact assessment has been developed, each of which has been thoroughly tested in one pilot area. The set includes frameworks for irrigation performance assessment, environmental performance assessment, socio-economic assessment and cost-benefit analysis, for the assessment of impacts of climate- and policy-related external drivers, and for social multi-criteria evaluation. Stakeholder group meetings served to jointly evaluate the findings from these assessments and to develop visions of a sustainable future in each pilot area.

PLEIADeS synthesis products

The main visible outcome of the project is summarized in this table of PLEIADeS synthesis products:

	Synthesis product	*Where to access it*
1	10 Factsheets on pilot areas (9 areas plus additional U.S. site)	Included in this report; Download on www.pleiades.es
2	9 videos on pilot areas (“Pilot Stories”)	www.youTube.es/pleiades8stories or through direct link on www.pleiades.es
3	SPIDER (system, Manuals, journal paper; Factsheet)	Demo access through www.pleiades.es; special page for users (use by licence agreement)
4	EO methodology package (including manuals, journal papers; Factsheet)	www.pleiades.es
5	6 thematic frameworks (documentation, journal articles, Factsheets)	www.pleiades.es
6	Pilot campaign datasets from 10 areas	Through SPIDER
7	Overview article (under revision)	Workspace on www.pleiades.es
8	Brochures in 7 languages	pdf for download on www.pleiades.es
9	Web portal with homepage in 7 languages and direct access to SPIDER and YouTube channel	www.pleiades.es

3 Work performed and results achieved

This Section 1.3 provides brief overviews of each workpackage and pilot area (slightly modified from the series of Factsheets, which can be downloaded from www.pleiades.es).

3.1 Stakeholders and their environments

3.1.1 Stakeholder analysis framework ("getting to know each other")

Objective To lay the foundations for the interaction and collaboration with stakeholders and to understand and describe the world of our stakeholders and their environment: pilot areas (irrigation schemes, aquifers, and river-basins), irrigation water management practices and stakeholder requirements.

Definition "Stakeholders are those, men and women, who have an interest in a particular issue, either as individuals, or as representatives of a group.
This includes people who make a decision, influence a decision, or can influence it, as well as those affected by it."

Key message

The active support of and collaboration with stakeholders is a prerequisite for any technical innovation to get a chance to be implemented. Story is a powerful means to foster collaboration and social learning.

What difference does it make?

Collaboration with stakeholders (or the lack of it) can make the difference between success and failure.

Contribution to and importance for PLEIADeS

The systematic and systemic work with stakeholders is one of the basic pillars of PLEIADeS. It strengthens the participatory process in a given area and prepares the ground for all technical and thematic development.

Methodological approach

We have used well-established participatory methodology for Multi-Stakeholder Processes (MSP) and classical stakeholder analysis, combined with Story (defined as a structured process to create multi-media content for the purpose of describing the historical, political, social, cultural context of our pilot areas). The following table gives an overview of the elements of the PLEIADeS basic stakeholder analysis.

There, the *stakeholder core group* is defined as those individuals or organizations who are the primary users of SPIDER (see 1.3.3.1) in a given pilot area. In accordance with the project's objectives, SPIDER is essentially a tool for water managers at irrigation scheme scale (main focus), but also for water resources managers at river-basin level (uplink) and irrigation farmers (downlink).
This has been a small group, different in each pilot area, typically composed of

- one (maximum 3) water manager(s) at irrigation scheme level; plus
- 1-3 water resources manager(s) /decision maker(s) at river-basin level; plus
- 3-5 irrigation farmers.

This group has been involved in the design, development, implementation, evaluation, dissemination and exploitation of SPIDER in each pilot area.

The *stakeholder control group* consists of a representative sample of all stakeholders in each pilot area. They have received all information from the project, including access to SPIDER, along with training and guidance in its use. They have evaluated the system from their perspective (each group member and the group in consensus if possible). Basically, they have evaluated the benefits and threats that PLEIADeS / SPIDER would bring to the different social actors in a given pilot area

Table. Elements of PLEIADeS basic stakeholder analysis.

Element / Task	***Approaches / Activities *)***	***Output***	***Purpose***
1 Historical analysis	Archives, literature, internet; Semi-structured interviews with key actors	Time-lines; Narratives	Part of Stories; May help in selection of stakeholder groups.
2 Institutional analysis		Map of institutional actors	Basis for selection of stakeholder core group; Material for Stories.
3 Stakeholder identification and top-level description		Stakeholder directory & map of stakeholders; Narratives	Basis for selection of stakeholder control group; Material for Stories.
4 Stakeholder groups identification and description	Analysis of output of steps 1-3 above	Directory of group members with detailed profiles of each	Steps 5-6 below
5 Stakeholder core group (=SPIDER Core Users)	Participant observation; Semi-structured interviews; Focus groups	Core User requirements for SPIDER, including evaluation criteria (document); Collaborative relationship (commitment).	Design, development, implementation, evaluation, & exploitation of SPIDER with active participation of Core Users at all stages; Material for Stories.
6 Stakeholder control group	Semi-structured interviews; Focus groups, including scoping exercise	Additional requirements for SPIDER (optional) (document); SPIDER evaluation protocol; Vision document	Evaluation of SPIDER and PLEIADeS & its effect in/on pilot area; Material for Stories.

Lessons Learned

This workpackage was one of the most difficult parts of the project. In many pilot areas the mostly technically oriented teams were lacking expertise and experience in the field of multi-stakeholder processes. At the same time, most partners were indeed aware that this work with stakeholders is also the most critical part and the one that determines the success of the project. So they started to find creative ways to team up with colleagues from other disciplines and/or institutions.

Do we have a Success Story here?

As a result of the multi-stakeholder process in each pilot area, we have completed the series of pilot area Factsheets and videos ("Pilot Stories"). Both have served the twofold purpose of providing attractive dissemination material and of fostering the participative process and dialogue among regional teams and stakeholders.

Policy recommendations

The participatory process in a given area can be consolidated and dynamized by using the synergy of Multi-stakeholder process methodology with Story and technical tools.

Key publications

Product	***Audience / purpose***
Factsheets (one for each pilot area) – available for download on www.pleiades.es	Policy-makers, decision-makers, Stakeholders, general public, media
Videos (one for each pilot area) – available on www.YouTube.es/pleiades8stories	Stakeholders, general public, media

3.1.2 The campaigns ("putting the tools into practice jointly with users")

Objective
To implement the PLEIADeS tools for irrigation water management in each pilot area and to evaluate their use in a participatory process.

Key message

Pilot campaigns are the means to effectively put into practice the collaboration of tool developers and users.

Contribution to and importance for PLEIADeS

The campaigns play a central role in PLEIADeS. First, they are the mechanism to **provide the required datasets** (field measurements, Earth observation (EO) data, additional data, stakeholder data and perceptions) that are needed to generate EO-assisted products for stakeholder test groups. Second, they **provide the frame of reference for the stakeholder evaluation process**.

Methodological approach

The campaigns were conceived in a flexible way providing only general directives and then adapted to the specific requirements of each pilot area. Thus, depending on each pilot area, the technical campaigns were conducted for different purposes and under different configurations and the stakeholder component was tuned to the water-related problems or conflicts in the area. In consequence, we have

- **one primary campaign objective** (common to all pilot areas): to provide stakeholders with the SPIDER system and basic products and to interact with them in a participatory evaluation process;
- **several secondary campaign objectives** (depending on each specific pilot area focus): development and validation of EO methodology (WP3 in Italy, Spain, Morocco, and Mexico), of irrigation performance analysis (WP4 testbed in Spain), of environmental performance analysis (WP5 testbed in Greece), of socio-economic analysis (WP6-1 testbed in Portugal), of social multi-criteria analysis (WP6-2 testbed in Portugal).

The pilot campaigns were operational campaigns conducted for an entire growing season (irrigation campaign). Some Core users have actually used the SPIDER system themselves, others have received products (some of them in near-real time). Participatory evaluation has been conducted with them continuously. The campaign protocol includes all of the following elements.

(i) image acquisition weekly or bi-weekly;
(ii) field data collection (weekly complementary field measurements of crop phenology and crop coefficient, height, fractional cover; plus agrometeorological station data);
(iii) generation of multi-level EO-assisted products in near-operational mode (at farm, irrigation scheme, river-basin level) according to operational processing chain defined in WP3 (including quality control);
(iv) upload of all products to SPIDER database immediately (both space and field segment);
(v) provision of information products to Core users and stakeholder control group (set up in WP1) at all levels (some in near-real time, i.e., 24 hours after satellite overpass) via web-based on-line SPIDER modules or email or in paper (depending on infrastructure available to user).
(vi) continuous participatory evaluation with Core users and other stakeholders.

Data and information flow (basically from top to bottom, with some iterative loops).

Input from where	WP1	WP2	WP3	WP4	WP5	WP6
Input what	Stakeholder groups & evaluation plan ↓	SPIDER incl. GIS of all pilot areas ↓	EO portfolio + methodology manual, including indicators from WP3-6 ↓	Irrigation performance indices definition	Environmental indicators / indices	Economic & social indicators
				All feed into WP3 + into eval framework ← and ↓		
				Framework for evaluation (eval) ↓		
Campaigns	Preparatory and pilot campaigns					
	↓	↓	Methodological campaigns ↓	↓		
Output	Campaign datasets ↓	↓	↓	New methods ↓		↓
What to do with it	Use in evaluation with stakeholders	Use in sMCA*)	Document & publish	Operational methods ↓		Research ↓
				Feed into updated EO portfolio		Journal publication

*) sMCA = social multi-criteria analysis

Do we have a Success Story here?

Each pilot area has successfully implemented SPIDER-global, some have also implemented their local SPIDER (always in line with the global system) and one or several components of the efficiency frameworks. Some users have become experts in using the tools. More and more users have become interested and have requested collaboration. In several areas, sustainable implementation beyond the project life time looks feasible.

Lessons Learned

A key element of successful implementation is to have a basic system/tool version available at project start and to train users and/or operators in all pilot areas early on. This opens the space for joint development and learning experiences on both sides. Even a basic system version gives everyone a tool to communicate in a practical way.

Policy recommendations

The PLEIADeS tools can be ideal policy instruments that facilitate the transition from mere infrastructure modernization to the next generation irrigation water management. They can be effectively used in the process of implementing the Water Framework Directive, components of the Common Agriculture Policy, and the Rural Development Policy.

Key outcome and publication

The campaign datasets are accessible online through the SPIDER link on www.pleiades.es.
Publications appear under the individual pilot areas.

3.2 Beyond technical efficiency: the multi-efficiency concept and frameworks

3.2.1 Irrigation performance ("efficient use of water")

Objective

To develop a framework and guidelines for irrigation scheme performance assessment aiming to irrigation management improvement through 1) a continuous learning process, and 2) comparison (benchmarking) with pair irrigation schemes.

Key message

Irrigation management improvement relies on sound performance assessment, which must consider the irrigation hydrological context. Performance indicators allow objective assessment.

What difference does it make?

For the first time, irrigation scheme performance assessment has been conceptualized in PLEIADeS WP4 as part of the new integrated water resources management paradigm. In an irrigation scheme, a part of the water that is distributed (through canals and pipes) and then applied to the fields is consumed (evapotranspirated) by the crops. The remaining water returns to the hydrological system. The return flows are usually considered as water losses. However, if those return flows can be reused downstream, they are no a loss if the domain of concern is the whole hydrological system. Therefore, the first step for irrigation performance assessment must be a clear definition of the boundaries of the system of interest.
Interventions or irrigation practices that improve system performance at the scale of a given domain (let say, an irrigation scheme) may have little or no impact on irrigation performance at other scales (for instance, the basin in which the irrigation scheme is located).
This has important implications: for example, a basin-scale programme aimed at increasing global irrigation efficiency (IE) should assign funds to increase on-farm IE only if reuse or the number of reuse cycles is small (Figure 1). Otherwise, the improvement of on-farm IE will have benefits for the farms themselves, but not for the whole basin.
Following this conceptual framework, practical protocols for quantifying irrigation performance, based on the water balance, remotely-sensed-ET and performance indicators, have been provided.

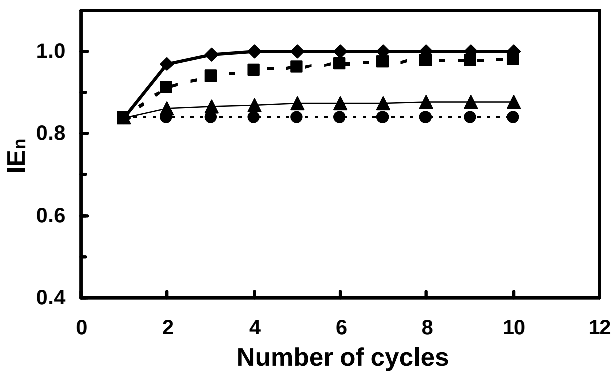


Figure 1: Irrigation efficiency (IE_n) of irrigation systems composed of n units. Diamonds represent irrigation units in series (cascade), circles zero reuse, and squares and triangles different reuse arrangement depending on the proportion of return flows that are recycled, reincorporated to the irrigation water source or lost

Contribution to and importance for PLEIADeS

Spatial patterns and temporal evolutions of remotely sensed ET are valuable when used for irrigation scheme performance assessment. Irrigation performance assessment is prerequisite for irrigation improvement, which will be truly achieved only if socioeconomic and environmental aspects are added to the analysis. Therefore, WP4 has been the link between the technological innovations (i.e., SPIDER) and the final goals of PLEIADeS.

Methodological approach

The methodological approach consisted of steps moving from a conceptual framework towards practical applications, through the definition of guidelines, performance indicators and analysis tools (models). These steps were:

- Analytical definition of the water balance and irrigation productivity concepts in complex hydrological schemes.
- Evaluation of water measuring devices and methodologies in the pilot irrigation schemes. Experimental evaluation of new, non-disruptive water measuring devices for determining water application in pilot irrigation schemes.
- Selection of irrigation performance assessment guidelines.
- Formulation of a water demand and distribution model for the simulation of alternative water managements in pilot irrigation schemes.
- Development of spreadsheets for computing water accounting and performance indicators in pilot irrigation schemes; compilation of results; and comparison (benchmarking) of irrigation performance.

<u>Activities and outcome in the WP testbed pilot area</u>

The testbed pilot area for WP4 has been Montijo, in Vegas del Guadiana, Spain. Activities began with technical meetings and visits to the scheme accompanied by managers of the scheme. Many managerial aspects were analyzed during these visits and discussions: water management constraints, prospects for improvement, data availability, data uncertainty. Using data available at the scheme or at Junta de Extremadura a GIS of the scheme was built. The layers in the GIS were: irrigation system layout, cadastral map, cropping pattern. Water supply data provided by the scheme manager was then added to the GIS database, and performance indicators were computed.
A parallel activity consisted in implementing the pilot scheme irrigation system in the water demand and distribution model, and simulating alternative water management scenarios. Following, discussion with the testbed pilot area manager and other stakeholders allowed identifying irrigation improvement alternatives.

<u>Activities and outcome in other pilot areas</u>

The same methodology and participative approach used at the testbed pilot were applied to the pilot area of Caia, Portugal. We performed an analysis of the water management constraints, prospects for improvement, data availability, data uncertainty. Then, a GIS database containing the irrigation system layout, cadastral map, cropping pattern, meteorological data…, was built. Finally, this information was used to run the water demand and distribution model simulating and comparing (by means of performance indicators) alternative water management scenarios.

<u>Do we have a Success Story here?</u>

Public administration officials and schemes water managers that initially were reluctant to introduce technically sound water management tools that are based on up-to-date science became more and more keen in understanding the benefits of such tools for supporting their water planning and water operation activities.

<u>Lessons Learned</u>

The new paradigm for irrigation system assessment, built on the concept of integrated water resources management, initially strikes water planners and managers. Therefore, it needs to be introduced gradually. Once it is understood, water planning and management policies become clearer.

<u>Policy recommendations</u>

Decisions about new irrigation developments or about rehabilitation and modernization of existing irrigation schemes need to be based on a conceptual framework for judging, planning and management policies under the new paradigm of integrated water resources. This framework should be the basis for the more complex, ad hoc models that planners should build for the specific water schemes of their concern. Remotely-sensed ET becomes then valuable as a precise estimation of the most relevant component of the water balance (the model principle).

<u>One key publication</u>

Mateos, L. 2008. Identifying a new paradigm for irrigation system performance. Irrigation Science 27:25-34

3.2.2 Environmental performance ("environmentally friendly irrigation")

Objective

To define a framework for the assessment of environmental performance (EP) o f irrigation systems; and to assess the potential to improve the environmental performance of selected pilot irrigation systems.

One key message

To improve Environmental Performance in sustainable agriculture and serve environmental protection policies.

What difference does it make?

The procedure is innovative, it is a new approach and the benefits to users are mainly energy saving and environmental protection for sustainable agriculture.

Contribution to and importance for PLEIADeS

It is significant component within the PLEIADeS project. PLEIADeS could provide information, expertise and recommendations to farmers and local authorities.

Methodological approach

A split-plot experiment was designed to evaluate the effect of irrigation level and nitrogen fertilizer rate on environmental performance of cotton in central Greece. Water and nitrogen use efficiency were the IOA environmental indicators that were specifically assessed. Supplementary indicators of ecosystem processes were used to interpret the output obtained by the IOA indicators. These included indicators of soil quality, crop nutrient uptake, crop stress due to water shortage and total nitrogen budgets. The split-plot design had 9 treatments where irrigation level was the whole-plot factor and the fertilizer was the split-plot factor (3 irrigation levels x 3 fertilizer rates x 3 replicates = 27 plots). Each replicate was subdivided into three whole plots (Figure 2). Irrigation levels were randomly assigned to the whole plot units to maintain a Latin square structure. The three rows were considered the 'row' blocking factor for the Latin square while replicate was the second blocking factor. The experimental field was located near the village Platikampos in the municipality of Platikampos (Larissa, Greece) at the coordinates 39^0 37´.34 00" ? and 22^0 33´.02 57" ? .

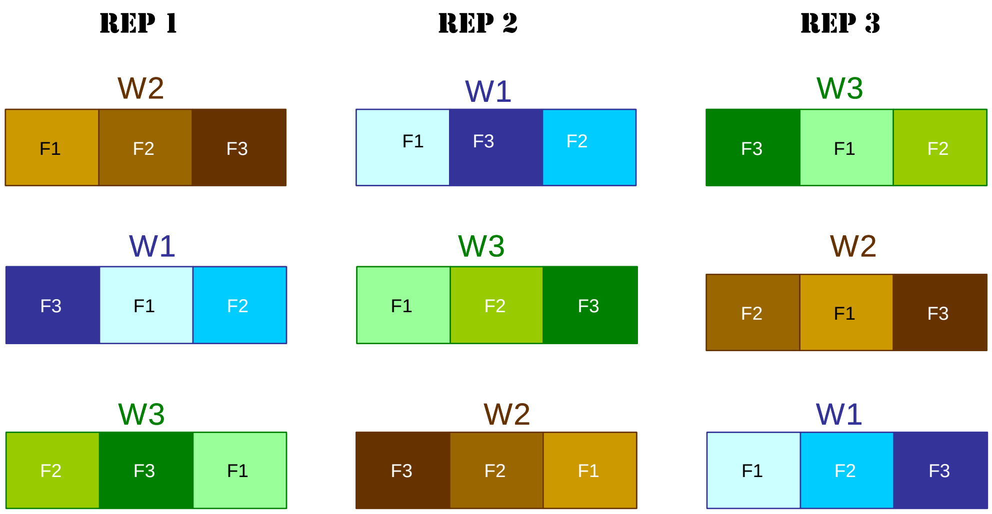


Figure 2: .The exact experimental layout in Platikambos (Greece). Each of the nine plots was treated with one of three irrigation levels (W1, W2, W3) and was split into 3 subplots that corresponded to the application of different fertilization rates (F1, F2, F3).

Data recorded for the environmental indicators for years 2007 to 2009 concern:

Table 1

Parameter	Information collection			
Pesticide use	Type	Quantity/ha	Cost/ha	Toxicity
Fertilizer	Type	Quantity	Cost	Toxicity
Tillage	Date	Cost/tillage	Diesel consumption/tillage	
Tiller	Date	Cost/tiller	Diesel consumption/tiler	
Soil grater	Date	Cost/grater	Diesel consumption/grater	
Mattock	Date	Cost/mattock	Diesel consumption/mattock	
Fertilizer distributor	Date	Cost/application	Diesel consumption/application	
Harrow	Date	Cost/harrow	Diesel consumption/harrow	
Pesticide sprinkler	Date	Cost/application	Diesel consumption/application	
Collector machine	Date	Cost/ pick	Oil consumption/pick	
Man-hours	Hours	Days	Cost	
Personal work	Persons	Period	Times a week	
Seed	Quantity	Cost		
Irrigation rubber	Cost of rubbers	Persons for setting	Costfor setting	
Production	kg/ha	Total		
Machines	Type	Cost /ha	Oil consumption/ha	
Water use	Date	Quantity	Hours	

Activities and outcome in the WP testbed pilot area

It seems there is an interest mainly by young farmers to implement PLEIADeS methodology to selected crops (cotton). However, this requires additional collaboration with stakeholders.

Activities and outcome in other pilot areas

Table 2

Pilot areas	Data for WP5	Commends
Caia	v	Some data is available
Vegas del Guadiana	x	
Nurra	v	Some data is available
Gediz	v	Some data is available
Tensift	x	
Ica	x	
Sonora	x	
Sao Francisco	x	

Do we have a Success Story here?

There is an interest by young farmers of the pilot area to follow and implement the methodology and procedure relied on demos provided for the fields that where used for the experiment.

Lessons Learned

It is a useful tool we need to expand and demonstrate its applicability and use and work with local authorities.

Policy recommendations

It may prove easier to start with the local authorities and try to develop an effective policy based on the results of PLEIADeS and later on try to generate a similar policy in a broader area.

One key publication

Samaras V., C. Tsadilas, S. Stamatiadis, C. Domenikiotis and N.R. Dalezios « Irrigation and Fertilisation effects on oil chemical properties and cotton yield». 11th International Symp. On Soil and Plant Analysis. Santa Rosa California, July 2009 (accepted).

3.2.3 Socio-economic performance ("socially and economically beneficial irrigation")

Objective
The Socio-Economic Assessment (SEA) framework provides a set of guidelines to support the socio-economic assessment exercise in each pilot area, valuating the key technical, economic, social and environmental aspects associated with alternative management options and contexts for irrigation schemes and farms.

One key message

SEA should be performed according to the diverse stakeholders perspectives (e.g. farmers, irrigation scheme managers, water managers, NGOs) and consider multiple aspects, dimensions and interests, generating results that are fundamental to the decision making process at several levels.

What difference does it make?

The SEA framework allows for:

1. Application in different socio-economic contexts.
2. Consideration of diverse perspectives and multiple dimensions.
3. Integration of direct and indirect monetary costs and benefits with any other relevant information and indicators.
4. Integration of relevant information obtained from stakeholder analysis (WP1), social multicriteria assessment (WP6-SMCA) and other work packages (mainly WP4 and 5).
5. Provides input for the SMCA process, as well as, indictors that can incorporated in SPIDER.

Contribution to and importance for PLEIADeS

The SEA exercise is developed considering the different viewpoints that stakeholders have.
The local water managers and farmers are primarily interested in the economic and financial viability of the irrigation scheme and farms, however, as citizens they are also interested in the economic and social contribution the irrigation perimeter will make to the region. River basin and national water managers are mainly concerned with the impact in water resources availability, water quality and the ecological dimension. The society in general is oriented towards the global economic, social and environmental impacts of irrigation. The integration of the economic and social dimensions in the evaluation of irrigation efficiency is considering the diverse viewpoints that stakeholders have.
The SEA framework also contributes with specialized indicators that can be an input for SPIDER.

Methodological approach

The framework is materialized in a set of variables and indicators in three main categories:

a. General: to provide basic information about the pilot area
b. Economical: oriented towards the economic viability and efficiency at the levels of farms, perimeter manager, as well as regional and national
c. Social: focused in the social context of the perimeter and the region

The SEA approach is performed in two different levels:

1. World-wide level / basic level: this includes only basic descriptors of the irrigation scheme, such as: perimeter and main crops area, main crops production, water use and taxes, irrigation costs and revenues, as well as general variables associated with employment, education and stakeholders' participation on water management
2. Test-bed level / advanced level: this includes additional variables and indicators, having a deeper detail of the information (e.g. per farm and per crop). In some cases, the development of a CBA (Cost-Benefit Analysis) study may be considered at the advanced level, for a more comprehensive assessment of the economic variables values.

Activities and outcome in the WP test-bed pilot area

In CAIA pilot area the advanced level of the SEA was implemented by CENSE/ECOMAN team. The crops selected for study in the pilot area were: maize, wheat, olive, tomato, sunflower and barley. The information was collected mainly in the following sources: a. ABCAIA (the perimeter water manager); b. Farmers; c.

National statistics and d. Experts in agriculture and agriculture economics. A special focus of our work was concentrated in fieldwork and interviews with main farmers, in order to collect raw data avoiding statistical bias. We were able to collect the data necessary for almost all variables and indicators that compose the advanced level (46 general variables, 33 economic and 16 social; 16 general indicators, 18 economic and 16 social).

Activities and outcome in other pilot areas

In all other pilot areas the basic level of assessment of the SEA framework was implemented (with 23 general variables, 17 economic and 8 social; 10 general indicators, 9 economic and 9 social).
These tasks were performed by PLEIADeS partners in each country, with CENSE/ECOMAN assistance. The information was collected mainly in the following sources: a. perimeter water managers; b. Farmers; c. National statistics and d. Experts in agriculture and agricultural economics.
Not all the information for the variables and indicators was collected in all pilot areas; the main gaps are related to economic data at the farm level.
An example of the results obtained for the comparative analysis of all pilot areas can be seen in Figure 3.

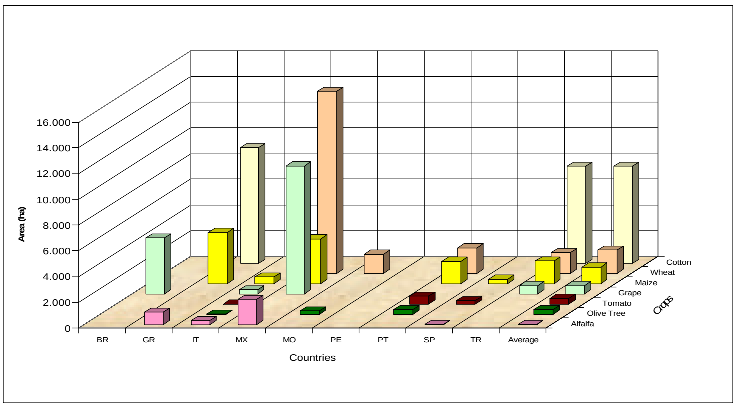


Figure 3: Irrigated Crop areas in PLEIADeS pilot areas

Do we have a Success Story here?

Yes, CAIA case study is a success. We were able to collect the information for the advanced SEA analysis, with a very good and informative support from the perimeter water manager and farmers. We also received a good feedback from various stakeholders about the importance of the SEA work, especially from farmers and the Ministry of Agriculture.

Lessons Learned

The farmers in Caia are aware about the economic and environmental impacts of water use in the future development of agriculture in the region. Nevertheless, in the majority of the cases, they lack systematic and detailed information that allows them to take preventive and proactive measures, employ best management practices, to avoid delayed reactions to scarcity indications. Therefore, adopting the SEA framework, as well as improving the dialogue between the different stakeholders, can contribute to the solution of the mentioned issues.

Policy recommendations

a. Improve dialogue between all stakeholders.
b. Promote the application of integrated assessment methodologies of economic, environmental and social issues.
c. Invest in the production, validation and dissemination of social and economical information, that can help stakeholders to implement better water management practices.

One key publication

Rui Santos, Pedro Beça, Paula Antunes. ”Socio-economic performance assessment of irrigation schemes: a 3-tiered flexible approach”. To be submitted to Journal of Sustainable Agriculture.

3.2.4 Impact of external drivers: climate change and policies ("adaptive need and potential")

> ***Objective***
> To assess the impact of climate change / variability on water resources in the pilot areas combined with an assessment of the impact of agriculture, water and rural development policies.

One key message

Successful adaptation to the impact of climate change / climate variability requires a sound level of preparedness on the part of decision-makers as well as on the part of individual farmers.

What difference does it make?

Future scenarios of the renewable water resources and their use in agriculture demonstrate that a 'business as usual' approach is not a viable option.

Contribution to and importance for PLEIADeS

Assessing the impact of external drivers and pressures is essential to prepare for a sound water management tomorrow.

Methodological approach

The conceptual framework developed within WP7 considers a sequence of steps:

1. Selection of 'best available' climate change projections.
2. Future scenarios of available water resources based on a historical trend analysis.
3. Evaluation of climate change impact indicators, including a comprehensive drought analysis.
4. Comparative analysis with observations obtained directly from stakeholders, including: farmers, irrigation advisory services/water user associations, river basin authorities etc.
5. Formulation of management scenarios that may represent adaptation to changing climate.

Assessment of Impact of Climate Change / Climate Variability in 9 Pilot Areas

Climate change projections found in the rapidly increasing literature have been collected in a **Reference Library of Long-term Climate Change Projections**. Apart from distinguishing between three time horizons (2010-2039, 2040-2069 and 2070-2100), each projection in the library comes with information on the type of model used. Regional Climate Models (RCMs) are considered to provide more reliable projections compared with Global Climate Models (GCMs), since the latter do not adequately take into consideration topography and land cover/vegetation. In several pilot areas, the 'best available' projections have been assigned to those issued from 'locally developed' models, usually representing recent research efforts aimed at further fine-tuning the projections down to the individual river basin or even sub-basin.

In parallel to this, a **Historical Trend Analysis** has been made of the monthly precipitation and temperature records of the meteorological station(s) within the respective pilot areas. Considering 1960-1990 as the 'reference' period, the data was used to provide a projection for the year 2025, which was then compared with the 'best available' climate change projection.

Across the Mediterranean pilot areas, climate change models and the historical trend analysis point to an average annual temperature increase of around 2 degrees Celsius in the short-term (2025), gradually increasing to around 5 degrees Celsius in the longer term. On a seasonal basis, the highest temperature increase is expected during summer. At the same time, rainfall is expected to reduce from 5% to over 30%, with climate change models generally predicting a higher reduction compared with the reduction derived from a historical trend analysis. Importantly, the most significant reduction in each of the Mediterranean pilot areas is expected to occur during winter, i.e. during the pluvial season. The combined effect of a reduction in rainfall and increase in temperature is responsible for the shift from dry/sub-humid conditions observed in the 1960s to the semi-arid conditions anticipated by 2025.

For the Tensift pilot area in Morocco, the analysis has been repeated for 2 meteorological stations. Analysis of the historical records for the upper part (Lalla Takerkoust dam) point to a shift from semi arid to arid conditions, while the lower part (Marrakech) of the Tensift basin is shifting to hyper-arid conditions. Sao Francisco pilot area in Brazil is characterized by low inter-annual variation in rainfall, while the most pluvial season appears to be shifting from March-April-May to December-January-February. For Sonora, Mexico and Ica, Peru the hyper-arid conditions, characterized by negligible amounts of rainfall, are set to continue also in the future. In all these pilot areas the annual temperature is expected to increase from around 1 to 4 degrees Celsius in the longer-term.

A **Drought Analysis** has been carried out using a number of recently developed approaches which are based on the calculation of drought indices. The analysis has been repeated by using different timescales for the calculation of these indices. On a 3 and 6 month timescale, the analysis can be linked to short-term drought events which affect the soil-moisture conditions in the field plot. Employing the 1960-1990 period once again as the 'reference period', the results indicate a very significant increase (over 25%) is expected in both the magnitude and duration of short-term droughts. On a 12 and 24 month time scale, the analysis can be linked to long-term droughts which affect river flows and groundwater levels. Here, the results have been used to establish a Drought Magnitude – Duration – Return Period relationship. From the diagram on the right, it can be seen that every 10 years, the majority of the Mediterranean pilot areas witness a drought of 30 months duration. This however increases to 40 months for the pilot areas in the Guadiana river basin, shared between Spain and Portugal.

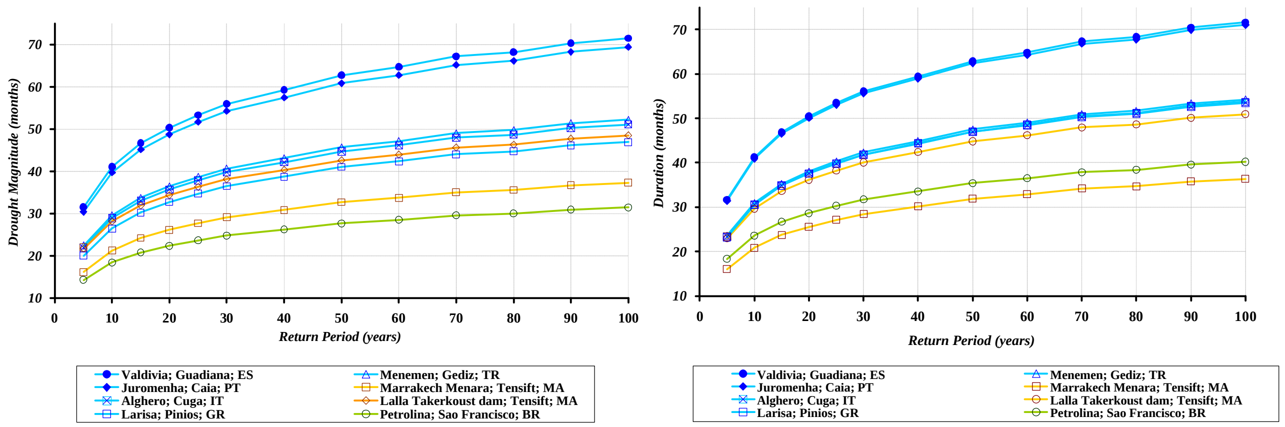


Figure 4. Drought magnitude – Return Period (left) and Drought Duration – Return Period (right) relationship, for each pilot area.

Comparative Analysis with Observations from Stakeholders

In several pilot areas, farmers' first hand experience of a changing climate has led to changes in crops cultivated as well as in planting times. In all pilots, farmers' own observations on the increased frequency and duration of droughts closely match the results derived from the above described scientific analysis. These are among the conclusions derived from a questionnaire on a range of key aspects addressed to "farmers" as well as to "authorities". The replies demonstrate the shared viewpoint on the urgent need for adaptation to climate change, and an equally strong consensus that this needs to be achieved, in order of priority, through: 1) the introduction of new policies, 2) changes in the irrigation system and 3) changes in agricultural practices. However, a sharp division in opinion emerges when asked about the means and effectiveness of guidance measures on how to mitigate the impact of agro-climatological hazards in the region, in particular droughts.

Future Management Scenarios

The impact of climate change points to an increased level of dependency of farmers on irrigation advisory services, who on their part are set to become more strongly dependent on the decisions taken by the river basin authorities. The key lesson learned is that urgent efforts are needed to step up a stakeholder driven, participatory water management, in which informed decisions and policies are reached through active consultation.

3.2.5 Social Multi-criteria analysis ("An integrated view")

Objective
To frame and structure the main issues related to irrigation in the PLEIADeS pilots, support evaluation of irrigation management alternatives and their effects on society, environment and economy, and to explore the potential of the MCA as an integrated water management support tool.

<u>One key message</u>

Participatory MCA supports strategic thinking on the way water is managed.

<u>What difference does it make?</u>

Strategic thinking serves not only to anticipate the future, but to reveal tools, knowledge and resources that exists and should be used at present. MCA may *enhance the decision-making process* (more transparency and integration of multiple stakeholders' knowledge) and contribute to *improved outcomes* (developed alternatives are portfolios of adaptive actions that can contribute to increased irrigation efficiency).

<u>Contribution to and importance for PLEIADeS</u>

In all PLEIADeS case study areas the increasing scarcity of water resources and their declining environmental status require the optimization of water use and changes in irriegies, combining socio-economic, technical and environmental aspects of irrigation. Besides this, MCA supports the design of the PLEIADeS new technology services by identifying stakeholders' expectations (link with the PLEIADeS objective: synergy between leading-edge technology and participatory management).

<u>Methodological approach</u>

Methodologically, we combine approaches of t*he Analytical Hierarchy Process – AHP* (Saaty 1977), and *Social multi-criteria evaluation – sMCE* (Munda 2004). Both methodologies foster transparency, reflection and learning processes simultaneously integrating multiple dimensions of the problem.
The general MCA framework is applied for *two levels of assessment*: *Advanced and Basic.* Advanced MCA is conducted in the Caia pilot area, Portugal, which is a WP6 «testbed». Basic MCA is applied to all others PLEIADeS pilot areas.

<u>Activities and outcome in the WP testbed pilot area</u>

In the Caia pilot, Portugal, focus is on *design, evaluation and comparison of alternatives in a participatory setting, encouraging direct involvement of stakeholders throughout the whole evaluation process.*
We aimed to develop a dynamic and flexible evaluation process, designed in a series of steps and facilitated by a synchronized application of different participation techniques: participant observation, interviews and learning workshops. We have organized two learning workshops: the 1st workshop served to re-frame the main problems of irrigation management in the area (information received during the first stage evaluation process) and to generate alternatives (problem solutions); the 2nd workshop was organized with the following objectives: to analyse and discuss a preliminary set of alternatives, to eventually identify new alternatives and identify evaluation criteria (including initial statements on criteria relative importance). The evaluation process is finalized during a second round of interviews: interviewees were supplied with a briefing paper describing each alternative (6), criteria (6) and subcriteria (13). In order to assist with their evaluation analysis, a rating sheet was designed to evaluate each alternative, showing the criteria and with the space for the individual ratings (and notes).

<u>Activities and outcome in other pilot areas</u>

In other pilot areas the evaluation process is based on qualitative assessments received from pilots' regional managers and the result of the analysis is just an overall assessment of the alternatives, which integrates information from WP1 and WP4-7. Basic MCA is developed in two stages, adopting basic MCA steps (see table 1). Communication with regional managers' and their feedback was indispensable in all stages of the analysis.

STAGES	MCA STEPS	Important issues / Questions
I STAGE	1. Identify decision context	Problem formulation Identification of social, institutional, political and economic context Main stakeholders
	2. Identify alternatives	Basic alternatives: BAU, BEST and WORST scenario. Other alternatives depend on the existing situation in the pilot area.
II STAGE	3. Identify objectives and evaluation criteria	Social, environmental, economic Max. 7 criteria Qualitative criteria scores
	4. Indicate criteria relative importance (criteria weight)	AHP procedure
	5. Alternatives evaluation	Understanding the problem from the different aspects Expert Choice software Basic MCA report

Table 3: Basic MCA workflow

Do we have a Success Story here?

Evaluation process in the Caia pilot, conceived in a series of steps and facilitated by the application of different participation techniques, presents clear evidence in support of increased participatory management in the field of irrigated agriculture. Splitting overall analysis considering different social groups (farmers, public authorities and experts) turned out to be a positive choice: instead of fostering dispute and intense discussion over one selected alternative, stakeholders had practically more time to reflect on each others needs, interests and way of thinking. In addition, trade-offs are clarified, identifying important conflicts across objectives, which is the main source of the complexity of the problem.

Lessons Learned

Decision process structuring facilitates continuous evaluation and reiterative learning processes. Separate analysis and discrete interpretation of the results reflects diversity in opinions, perspectives and preferences. These differences can be used by analysts (and stakeholders) as a source for alternatives of further adaptation and change.

Policy recommendations

- Increase incentives and resources for capacity building of farmers' community, encourage them to participate and act, use their knowledge to empower them.
- Effectively use experiences from this project and (MCA) evaluation results, seeing alternatives as a range of actions, or "desirable policy mix" for possible future action.

One key publication

Antunes, P., Santos R. And Karadzic, V. Participative multi-criteria analysis for the evaluation of irrigation management alternatives. A case of Caia pilot, Portugal, submitted to International Journal of Agricultural Sustainability (IJAS).

3.3 Tools: "Technology for participation"

3.3.1 SPIDER: "e-connecting information and stakeholders"

Objective
To develop a multi-level interactive tool for irrigation water management connecting farm, irrigation scheme, and river-basin level and implement it for each pilot area.

One key message

The **S**ystem of **P**articipatory **I**nformation, **D**ecision support, and **E**xpert knowledge for irrigation and **R**iver basin water management (SPIDER) contributes significantly to factilitating participatory process and collaboration of all stakeholders and to enhancing transparency in irrigation water management.

What difference does it make?

Combining Earth Observation Technologies with web-based GIS offers an environment for exploring and analyzing spatial temporal data and monitoring evolution of crops and natural vegetation, as well as estimating water consumption in wide regions of land. This kind of functionality is not available in any other similar software and accessing it in a distributed way provides a platform for an agile and transparent management in irrigation water domain, and it can be applied to other domains as well. Apart from that, SPIDER can connect with external Web Map Services, offering the option of comparing and combining the data from SPIDER with other official and non-official data available in the network based on Open Geographical Consortium standards, which are widely used, specially in Europe due to initiatives like the European directive INSPIRE. It is also important to mention the benefits that SPIDER offers to the scientific environment for publishing and sharing research results, and for promoting the collaboration between the different hierarchy levels in irrigation water management.

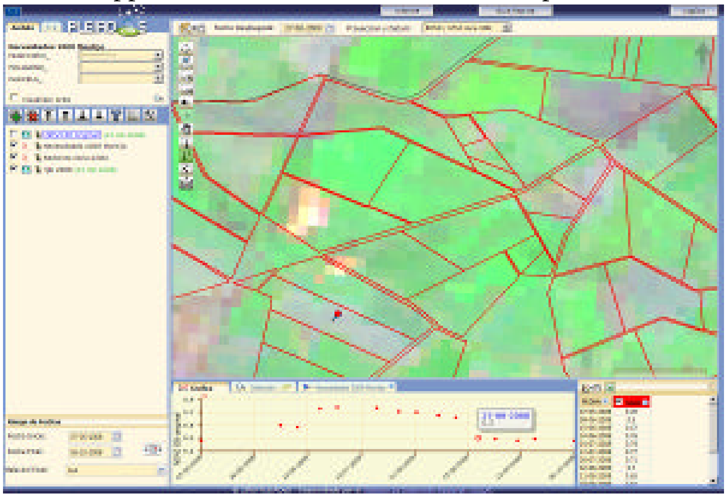


Figure 5. A snapshot of SPIDER functionality

Contribution to and importance for PLEIADeS

Firstly, SPIDER is the first medium to share and publish other work packages outputs. It has been also possible to use the system as a way of communication and calling attention for the different users involved in irrigation water management. Having this platform for all project groups has also made possible to offer them a way of communicating and sharing knowledge, even for those groups which are geographically located far away. The following conditions can summarize SPIDER contribution to PLEIADeS as:

- the platform to disseminate and share scientific knowledge within the academic environment;
- the bridge between scientific results and its use for society's benefit.

Secondly, the work developed in this work package has helped capacity building of the teams involved in the project for the use of those kind of technologies, introducing concepts and vocabulary related with this domain of Information Systems, improving and adapting the existing processes and creating new ones for data generation. This has provided an interaction between the work package members and the other PLEIADeS groups which proved very useful for improving data processing skills.

Methodological approach

The SPIDER design is based on a client-server architecture. The server side covers both data storage and complex functionality and it provides access for the client application to this functionality and data. The web client application has been inspired by the new Web 2.0 wave and is based in dynamic web programming languages, which makes possible to provide light functionality in the client's side, and a very friendly and attractive interface for SPIDER users without having to install anything. In order to reuse already available technologies, and also as a way of providing a feedback to community, the implementation of SPIDER is based on open source technologies and libraries, so that it has been possible to focus development in SPIDER users needs, as well as to warranty that the outputs of this work package revert back into society.

The strategy to make available the system and disseminate it by the different pilot areas has been based on the concept of a Global SPIDER, where each pilot area could upload data into the system. This provided a first step of learning SPIDER use for the groups, so that those able to install and configure their own local SPIDER (e.g., in Perú, Mexico or Morroco) according to their requirements. Also this idea has provided the opportunity of cross-border collaboration in the pilot areas in Portugal and Spain, using shared data for the regions of Caia and Guadiana Medio.

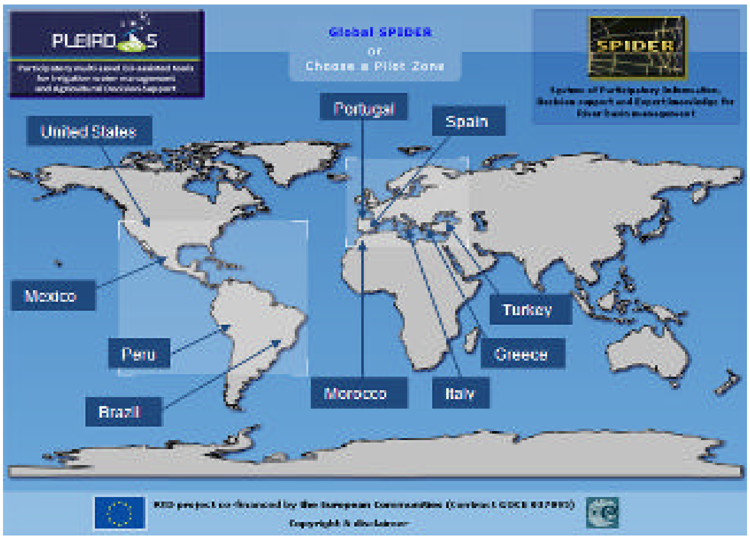


Figure 6. Homepage of Global Spider.

Lessons Learned

The first conclusion is that traditional data production processes need some adaptation to the new technologies and standards in most cases. It is necessary to be ready for the new revolution that the web is going to witness, becoming the most important and open data network. Mobile devices are the future for accessing those data from the field, but the ways of exploring data is probably not the same as for the web client application. The evolution of new mobile generation is important, but a lot of work remains to do. In the meantime, the attention on those new technologies for sharing and exploring data must be maintained. Its potential for improving irrigation water use and management and for raising awareness of the general public on the importance of a responsible use of water is huge.

Policy recommendations

The use of those kind of technologies, provide official institutions a tool for improving the interaction between the different stakeholders involved in water management decisions, improving the communication and the habits of working together between all the existing levels. Another important issue to take into account is that transparency is one important bridge to accomplish this objective.

One key publication

Moreno-Rivera, Juan Manuel, Anna Osann, y Alfonso Calera. "SPIDER - An Open GIS application use case." In First Open Source GIS UK Conference. Nottingham, 2009***.***

3.3.2 EO Portfolio: "Monitoring crop growth from space"

Objective
Harmonization of Earth Observation (EO) methodologies for use in operational irrigation water management, aiming to quantify accuracy and conditions of applicability of different methods to estimate crop water requirements (with special concern to reference, potential and actual evapotranspiration).

One key message

Earth Observation (EO) provides an **objective evaluation** of crop water demand; this information can be used at different decision levels (from the farmers to the river basin authorities) to promote a more efficient use of water resources in agriculture.

What difference does it make?

A rational management of water resources for irrigation requires information characterized by high temporal and spatial variability, which can not be monitored with traditional field inspections. Earth Observation is a mature technology, ready for being transferred to operational applications in agricultural water management. Detailed data on crop development and irrigation needs are timely distributed to final users by means of modern Information and Communication Technologies (Figure 7).

Figure 7. Evaluation of crop water demand using remote sensing

Contribution to and importance for PLEIADeS

Within PLEIADeS, two main usages of EO-based products have been conceived:

i) Distribution of personalized information to a range of stakeholders (i.e. landowners, irrigation farmers and their associations) concerning crop and water status;
ii) Integration in GIS-based river-basin water management tool, for distributed water balance calculations.

A portfolio of EO-based products has been set-up, and the methodologies for their retrieval have been defined, starting from past experiences and scientific knowledge available among the partners in the Consortium. F.A.O. methodology has been adopted as the standard procedure for computing crop water requirements from EO-based products. Three different levels of EO-based products are distinguished in PLEIADeS:

1) LAND-USE (irrigated vs. non irrigated crops; crop inventory maps).
2) BASIC (vegetation cover, Leaf Area Index, Crop Coefficients, potential evapotranspiration, Crop Water Requirements among others).
3) ADVANCED (reference and actual evapotranspiration, biomass, yield).

Methodological approach

The conceptual approach for the derivation of E.O.-model of the service is split up into the following steps:
1. Acquisition and analysis of high resolution satellite images in the visible and infrared spectrum;
2. Local agro-meteorological data acquisition (e.g. temperature, humidity, wind speed, sun radiation, rainfall);
3. Field validation through measurements in selected areas;
4. Elaboration of E.O. based products;
5. Data quality check and integration in a dedicated Geographical Information Systems (GIS) for irrigation management from field to district and hydrological basin scale
6. Real-time distribution of personalized irrigation advices on a weekly basis directly to farmers by means of different communication systems (Internet, text and graphical messages by using GSM/UMTS)

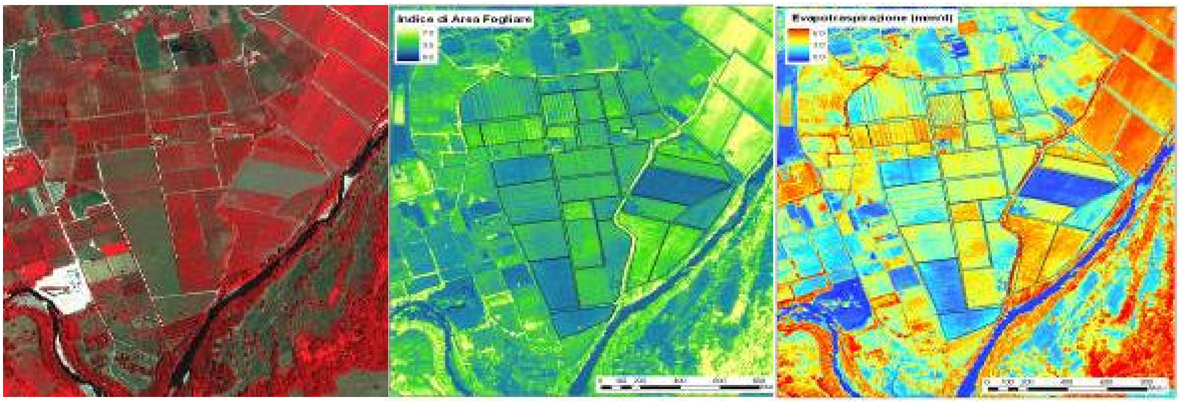


Figure 8. Analysis of high resolution satellite image to produce required information layers

Activities and outcome in pilot areas

The validation of the different methodologies for the retrieval of E.O.-based products has been an important part of the work carried out within PLEIADeS in all the pilot areas (Portugal, Spain, Italy, Greece, Turkey, Morocco, Mexico, Peru, and Brazil). Intensive field campaigns carried out simultaneously to satellite acquisitions have produced a large data-set for calibration and validation purposes. Micrometeorological instrumentations have been installed for comparison between field measurements of crop water use and estimates from E.O. processing. New methodologies have been set-up i.e. for improving the estimation of canopy parameters and for calculating reference evapotranspiration from geostationary satellites (of particular relevance in areas with very limited meteorological data).

Happy end: technology increasing awareness

The mutual interaction between the scientific partners of PLEIADeS and the final users – representing the main players for the water management in the pilot areas – has produced an increased awareness toward a more rationale utilization of water resources in irrigation. In most areas satellite images have revealed spatial patterns of crop water demand with unprecedented clarity and objectivity, thus improving the definition of strategies for the allocation of water resources and reducing potential conflicts among different users.
Diversely from what could be expected, the technological transfer to the farmers was a very quick process, with beneficial effects on production and economical revenues.

One key publication

Development and validation of Earth Observation products for operational irrigation management in the context of the PLEIADeS project. Authors: G.D'Urso, A.Calera, M.A.Osann, K. Richter, F. Vuolo et al.; submitted to Agric.Water Manag., Elsevier, 2009.

3.4 Pilot Stories

3.4.1 Caia (Portugal)

Low efficiency of water managing operating and distribution system influence its use. Distribution system has several problems associated such as, water loss by evaporation, water quality decrease and an inefficient water management ordering system. In addition, different rules for managing and using water, for different properties, make functioning of the system complex and not feasible in the long run.

Geographical location and political context

The *Caia river watershed* (Portugal) is located near the border between Portugal and Spain. It is a sub-basin of *Guadiana International watershed* with an area of 571 Km^2. The dam has an overall capacity of 203 millions of m^3 and a useful capacity of 192 millions of m^3, used for agricultural and urban water supply for the municipalities of Campo Maior, Elvas, Aronches and Monforte. The Caia Irrigation district (AHCaia) covers an overall area of 9000 ha where 7240 ha are irrigated.

Figure 9. Location and extent of the pilot area on the frame of Guadiana River in Portugal.

Historical development

The first known studies, related with Caia Dam have been carried out during 1884, by the Alentejo's Water Management Commission. It was thoroughly reviewed fifty years later, between 1933 and 1938 by the Agricultural Hydraulic Works Autonomous Board, integrated on the Direction of Hydraulic Services. The construction of the Caia Dam started during 1962, the dam was inaugurated in 1967, integrated in the frame of the Alentejo, Irrigation Plan.

Current situation of people

The Caia area is embedded in an extensive monoculture agrarian and economic structure, based on wheat and crop husbandry, typical for the entire Alentejo region, with low population density and weak industrial development, socio-economically peripheral. Recurring work crises and rural desertification have negative impact on the rural development, with consequences on migration inside Portugal and abroad. This is also related with the low productivity and land capability of some soils and due to extreme climatic conditions with concentration of rainfall during autumn/winter, being very low during spring /summer.
The Caia irrigated area plays a special role in this context, with big impact on the local socio-economic development, allowing the settlement of new agricultural managers open to innovation. Several of them, among them two women, have adapted new technologies and tools.
The increasing prices of production factors and the large variation of the crop market prices has been leading to a significant change from traditional to more profitable crops, e.g., in big holdings with olive trees, some

orchards and milk production holdings, managed by foreigners, some of them belonging to large economic groups.

Current situation of river-basin / aquifer

Agricultural use demands 80% of the available water, for an irrigation campaign between March/April and October, while urban use consumes 10%.
A two main Canals Campo Maior and Elvas constitute the irrigation system, with a secondary network. There is a system supported by the two pumping stations of "Vale Morto" and "Carrascal", to improve water distribution. The irrigation system has a flexible frequency and flow rate and fixed duration (diurnal or nocturnal).
On farm irrigation is mainly based on pressurized systems, with drip irrigation for tomato and olive trees and sprinkler irrigation (center pivots) for maize, wheat and sunflower.

Future perspective

With the use of new irrigation technologies and the increase of olive tree area, a reduction of water use is predicted, but not a water deficit, due to the fact that the availability from the dam is around 60 millions m^3 and annual availability is around 80 millions m^3.
A permanent climatic irregularity, more for rainfall than temperatures, as possible changes, due to the Mediterranean Continental Climatic conditions, gives Caia an important position as a study area for the increase on efficiency use of water for agriculture, in accordance with the implementation of the Water Framework Directive (WFD) and its environmental requirements.

Conflicts

The area does not normally suffer from a systematic water deficit. During 40 years of irrigation campaign, only three years were under pressure for water losses, two of them with a low amount. Consequently, no important water conflicts have been observed.
During the last three years significant changes in land ownership have taken place, as a direct consequence of agrarian policy, together with price instability and a non controlled increase of cost of production factors. Because of this some farmers sold their lands to big economic groups increasing the price of land. This intensive use of land should be carefully followed and monitored, in view of its potential impact on groundwater and environment.

Role / weight of principal actors

INAG (National Water Institute) is the entity in charge of the implementation of the Water Framework Directive at national level. It also has the responsibility for the planning of water use and management. CCDR (Regional Coordination of Regional Development) units have the responsibility of the management of water for agriculture. More recently the Hydrographic Regional Administrations (Arhs) have been created, being the Arh - Alentejo the one that covers the Caia area.
MADRP (Ministry of Agriculture Rural Development and Fisheries) has the responsibility to apply CAP (Common Agricultural Policies), promoting Rural Development in accordance with environmental protection, through the use of good agricultural practices. The National Irrigation authority is DGADR (General Development of Agriculture and Rural Development), coordinating political orientations and irrigation infrastructure in cooperation with Regional Directorate of Agriculture and Fisheries from Alentejo.
The Caia pilot zone is managed by the Associação de Beneficiários do Caia (ABCaia), established during 1968, in charge of the maintenance and conservation of the entire irrigation system, the water distribution and the implementation of new irrigation systems.

What can PLEIADeS contribute?

The receptivity and the interest of farmers in cooperation with the Associação de Beneficiários do Caia, in the development and improvement of methods for a more rational use of water, allowing the use of their fields lead to important results and outputs for the future of irrigated farming. Also SPIDER can be assumed as an important tool for the dissemination of technical, economic, social and environmental data, in order to improve communication, between different users and stakeholders related with water management at local, regional and national level.

3.4.2 Las Vegas del Guadiana (Spain)

The irrigable area of the Guadiana on its way through Extremadura has a surface area of 123.000 ha. Despite the fact that the reservoirs in the past five years have not exceeded 60% of total capacity, the regulation model of the Guadiana river in the region allows the sustainability of irrigated crops. However, it is necessary to implement integrated systems of water management in order to improve efficiency in water use, to prevent aquifer contamination, enhance ecological flows and face the future water needs without resorting to new water reserves.

Geographical location and political context

Extremadura is located in the southwest of Spain. There are two main rivers that cross Extremadura from east to west: Tagus in the north and Guadiana in the south of the region. The PLEIADES Spanish pilot zone is focused in the lands wetted by Guadiana River. The irrigated area is over 120.000 ha and is divided clearly at bird's eye into two main areas (coloured in red), known as Vegas Altas and Vegas Bajas, separated at the height of the Extremadura capital, Mérida (Figure 10).

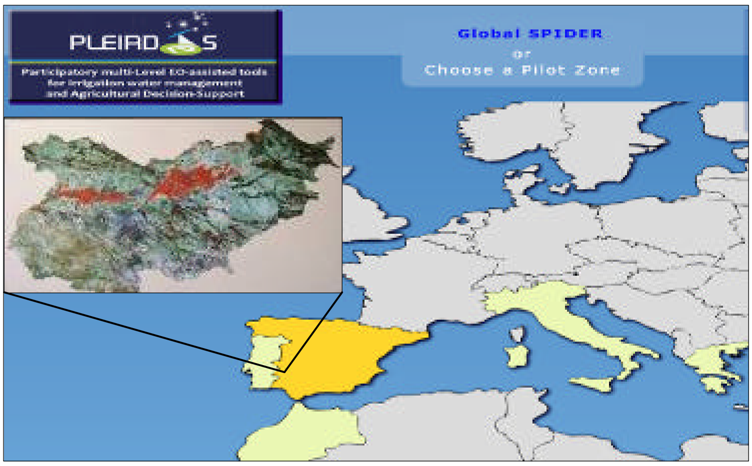


Figure 10***: Vegas del Guadiana pilot zone overview using the SPIDER System***

Historical development

Until the 20s and 30s of last century the land in Extremadura was distributed in large states among a handful of families. The seasonal unemployment and recurrent famine in the years of adverse weather conditions caused social tension. During the period of the second Spanish Republic it was approved the Agrarian Reform Law which together with an Hydraulic Plan intended for the redistribution of land to small owners and start-watering Guadiana river Lands. The "coup d'etat" of 1936 and the subsequent civil war interrupted the development of the law and the infrastructure works. Subsequently, these plans were picked during the dictatorship of Franco (1939-1975). The regulation works to built dams and canals have been continued and improved during the democratic stage (last 30 years). Currently, irrigation facilities are being improved through replacement of open canals by pipes and, where there are pressurized irrigation systems; remote control systems are being installed.

Current situation of people

Currently, there are large farms with small ones integrated into large cooperatives. The development of agricultural industries has provided new jobs.
However, Extremadura is the Spanish region with the lowest income per capita and also the one which has the higher percentage of unemployment. That is why water resources are probably a development opportunity for the future, the opportunity to bring to the people a standard of living near to the national average.

Current situation of river-basin / aquifer

The maximum water reservoirs in Extremadura are 7500 Hm^3 although in the past five years, the stored water has not exceeded 60% of its capacity. As a result of that there have been restrictions for irrigation in some areas. Fortunately the regulation of the Guadiana River on its way through Extremadura generally allows the delivery of all claims, thanks also to the distribution of the irrigable area and reservoirs along the river, which enables reusing 25% of the water used.

Future perspective

In a scenario of climate change is expected a smaller volume of water stored and a higher level of evapotranspiration. If we add to this the prospect of industrial development in the region, currently non-existent, the expected increase of population and the impossibility of building new reservoirs from environmental and social points, it is not alarmist to say that the actual reservoirs will not be adequate to the future demands. It is necessary, therefore, make efforts to improve water use efficiency if we want maintain the actual irrigated surface and further improve the ecological flows of Guadiana river and their streams.

Conflicts

New industrial uses of water could reduce water availability for crop irrigation.

Role / weight of principal actors

La Confederación Hidragráfica del Guadiana (water institution at the national level) manages the water reservoirs and in most cases also the main channels. The irrigation communities (farmer associations) manage water distribution in second canals and ditches and also the maintenance.

Currently, efforts are being made to transfer the jurisdiction of the main channels for the communities, in order to manage irrigation infrastructure and water distribution directly, which is expected to be translated into increased efficiency in water use and lower water costs.

What can PLEIADeS contribute?

The contribution that PLEIADeS can make to improve efficiency in the irrigation and management of the water is different in the case of the irrigable area of Vegas Bajas (Montijo) and Vegas Altas (Zújar).

In the case of Montijo, the high fragmentation of the land prevents in many cases the determination of the water needs of crops by the use of satellite images, due to satellite spatial resolution. Furthermore, despite Montijo is an area where it is more necessary to increase the efficiency of irrigation water, it is more difficult to implement in practice the results of PLEIADeS, because the limiting factor to use more efficiently the water is transport infrastructure and also the system of application in the field.

However, due to the high frequency we get satellite images (8 days) and it is possible to make continuous monitoring of crop development and to reach satisfactory results working at the sector level or irrigable area.

In the case of Zújar, the limiting factor for the application of remote sensing is the frequency we get satellite images, 16 days. However, the larger size of farms, the actual installation of a remote control system that will run on 100% in the next campaign and the direct management by the community’s irrigation of the canal, would allow a direct use of the products PLEIADeS at the level of irrigation community and also at the level of individual farmers.

3.4.3 Nurra (Sardinia, Italy)

Nurra area (NW Sardinia) and in general Sardinia has low water resources availability due to the peculiar geographic position. It can be considered a representative site for a pressing issue widely spread in the whole Mediterranean Basin: water scarcity. The water resources deficit determines a strong conflict among the various uses (agricultural, industrial and civil).

Geographical location and political context

Nurra test site is located in the North-West part of Sardinia in the territory of Sassari Province. In this area is located the Calich river Basin to which belongs the municipalities' territory of Alghero, Ittiri, Olmedo, Putifigari, Sassari, Uri and Villanova Monteleone, the total surface is about 430 square kilometers. The basin can be divided in two large parts: the "Nurra di Alghero", with flat topography zones located in the northern-central portion of the basin and an area made up of hilly zones extended from Alghero to Villanova Monteleone, located in the southern portion of basin. Inside the basin there are two artificial lakes: Cuga and Surigheddu Reservoir. Water allocation in agriculture is managed by the Nurra Land Reclamation and Irrigation Consortium, with a territorial extension of about 80,000 ha. (Figure 11)

Figure 12: Nurra pilot zone using SPIDER System.

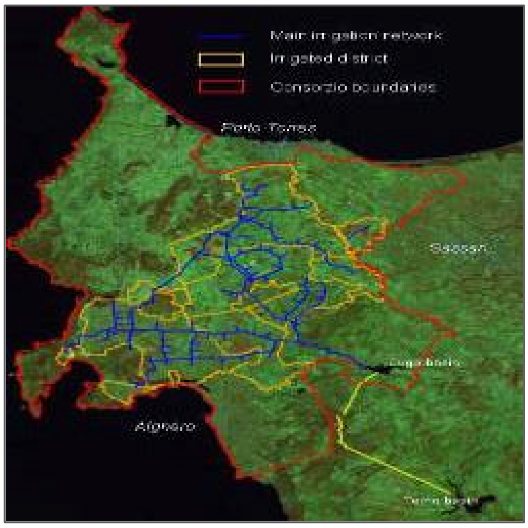


Figure 11: Nurra irrigation scheme network.

Irrigation Context

The main gathering works are represented by two artificial reservoirs along the river Temo at Monteleone Roccadoria (maximum adjustment volume 91.2 millions of m^3) and along the River Cuga at Nuraghe Attentu (maximum adjustment volume 34.9 millions of m^3). The irrigated district, served by a water distribuition system, has a total surface of about 27,600 ha equivalent to an irrigable surface of about 15,500 ha annually. Actual fact due to water shortage and conflicts among water uses the irrigated surface is downsized to about 4,000 ha.

Irrigation network is composed by:

- a main convey infrastructure between 2 reservoirs and the irrigation network with a length of 25 Km;
- about 1,300 km of irrigation network (adduction and distribution pipeline);
- 15 water deposits with a total capacity of about 208,000 m^3;
- 11 pump station with a total flow of about 8.75 m^3/s.

The most important irrigated crops are: maize, alfalfa (for ovine and bovine breeding) and vineyard.

Historical development

After the Nuraghe civilisation the site experienced, during the centuries, occupation from different peoples (Carthaginians, Romans, Arabs, and Spanish) who contribute, establishing several activities such as cereal cultivation, pastoralism and breeding, which led to demographic increase.

The Savoy reign (1720-1920) tried to rule and manage the land to keep a balance between livestock and scarce sources of water. The land was completely privatized, but there weren't land investments. Therefore, the territory was still poorly populated with subsistence farming. A big colonization and reclamation works were lead by the Ente Ferrarese di Colonizzazione during Fascism (1920-1942). It allowed cultivating large areas of Nurra. The Second World War (1942) stopped the reclamation. On 1949 it was constituted the 'Consorzio di Bonifica della Nurra', first created among Public Entities in 1949 and then among private owners in 1963 who have worked on irrigation network, viability, construction of public services (water wells and rural electrify).

Current situation of people

In general the agriculture sector is characterized by an hard status of crises due to the overprice of raw materials (fodder, fertilizer, etc.), gasoline and for the low price of agriculture products.

The consequences have been the change of agriculture's structure. Husbandry's farms changed their land use from arable land, used for pasture, to other more high-value crops like olive trees and vineyards. This allowed the development of important wine farms (e.g. Sella&Mosca) and cooperatives (e.g. S.M. La Palma with 326 growers contributing to the winery).

Current situation of river-basin / aquifer

Some adaptation measures have been implemented by Nurra Consortium for the 2008 irrigation season (i.e. water saving strategies, water wells use authorization). The measures were adopted to counteract autumn-winter drought and the increased water request for civil use (due to tourism).

Future perspective

The continuous growth of the tourism industry promoted by the presence of worthwhile ancient places and wonderful natural landscapes coupled with the recent development of new infrastructure and cheap transportation operators can have positive effects on agricultural sector.

Potentially agricultural activities could benefit from the increase of high-value crops demand (e.g. fruits and fresh vegetables) and probably the area could experience further changes in land use.

Conflicts

Conflicts among the three main water uses (civil, industrial and irrigation) affect the area especially during summer and drought periods that have been occurred, during the last years, with a 5 years cycle (1985, 1990, 1995, 2000). The issue is more evident in the summer when the water demand of drinking water raise due to the increase of population for tourism.

Role / weight of principal actors

The water management in Italy is organized into four levels: central, regional, river basin authorities and land reclamation consortia. Central level defines a specific program "*Programma Nazionale degli interventi nel settore idrico*" (a general planning concerning the infrastructural investment for the irrigation sector). The program is realized following the needs expressed by Regional government, who receives in turn indications from land reclamation consortia, concerning irrigation.

Water management at regional level is under control of E.NA.S (Ente acque della Sardegna) who supervises the multi-sectorial water system for mixed use included works, plant and infrastructure, while the public water utility company Abbanoa spa manages the public water integrated service based on collection, adduction and distribution of water for civil use, sewers and purification sewerage system.

Nurra Land reclamation and Irrigation Consortium manages the irrigation water.

What can PLEIADeS contribute?

PLEIADeS and its experimental results can provide useful information to address drought phenomena namely enabling the adoption and implementation of specific and efficient measures to combat the drought.

In detail the implementation of SPIDER can improve water use efficiency both at farm level and at consortium level allowing to a better management of extreme events that generally cause drastic reduction or even a closedown of irrigation water supply. In addition such system could be exploited by Consortium for undeclared irrigated areas detection.

3.4.4 Pinios (Greece)

> High agricultural productivity area producing high quality products, irrigated by river Pinios, drillings and reservoirs. The main issue is the lack of irrigation water. The local irrigation authorities maintain a reasonable infrastructure with certainly requires significant upgrade towards an effective water management in the river basin Pinios.

Geographical location and political context

The region of Thessaly overtakes the central - Eastern department of continental Greece. It is constituted by the Prefectures Karditsa, Larissa, Magnesia and Trikala and overtakes total extent of 14036 Km^2 (10.6% of total extent of country). The 36.0% of ground are in a plain, the 17.1% semi-mountain, while the 44.9% is mountainous. High mountains surround the plain of Thessaly, which constitutes the bigger plain of country that divided westwards to Eastern from the river Pinios that is the third bigger river of country. (Figure 13)

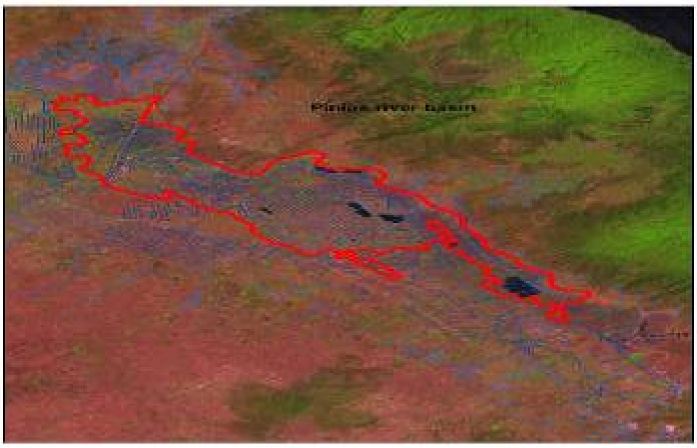


Figure 13: Geographical location.

Historical development

The prefecture is lived by Paleolithic years. Samples of life were located in the banks of river Pinios, near Larissa that is dated in 100000 - 70000 B.C. Mesolithic tools of 8th millennium B.C. were found in the lake Boibiida in Kastri. People were farmers and cattle-breeders, domesticate the dog and lived in huts. Larissa was the capital city of Pelasgiotidas, one of the four Thessalian tetrarchies. From the end of 7th century B.C. prevailed absolutely in large extent of fertile Thessalian plain and played fundamental role in the eventful history of Thessaly. 6th and 5th century B.C. Larissa was in acne. In the devastating Peloponnesian War citizen of Larisa were come out in side of Athenians, but afterwards 404 B.C. burst out disputes and litigations between the oligarchic parties that claimed the power. The rich landowners presented more democratic. The Christianity was propagated by the 1st century. At the end of 11th century Norman depopulated once again Thessaly, with continuous raids until 1156 that Alexios A? Komninos chase and signed treaty. Frankish domination last from 1204 until 1222. Later undertook the administration the despots of Continent and other Byzantines noble, until 1333 that the Thessaly came back in the Byzantine state. In 1342 follow the Serbian conquest of Stefan Doysan and the blossoming of monasterial life. From 1936 presented the Turks that completed the occupation in 1423. The residents were pulled in the mountainous, where later flourished the fellow-craftsmen of threads and dye and the export trade, activities that encouraged the conqueror for his own profit. The economic growth brought also the intellectual rebirth, rebirth, with better educated school teachers. In 1821 Thessalians rebelled, but hardly in 1881 was blamed the region in the Greek state.

Current situation of people

The population of Region Thessaly amounts in 743.075 residents according to the estimate of Greek National Statistical Organisation that represents the 7.1% of total population of country. It constitutes the third in demographic size Region. The demographic density of Region is 52.9 residents per Km^2. The urban population amounts in the 44% of total population and presents increasing tendencies. The rural population amounts in the 40% of total and it presents fall, while the semi-urban population progressively increases and amounts in the 16% of total. The GNP (Gross National Product) of Region Thessaly is lower corresponding means per capita GNP of country. The region produces the 6.6% of total Crude Domestic Product of country. In the primary sector are produced the 35.5%, in the secondary 22.4% and in the tertiary sector the 43.1% of regional Crude Domestic Product. Diachronically, is observed, small tendency of turn of regional economy to the tertiary sector, after is increased the attendance of this sector in the total regional GNP and small bending of primary and secondary sector. With regard to the productivity, the Region is found in lower level than the country. Concerning the European Union the productivity of Region is in the 68% of mean of EU. Workforce of Thessaly amounts in 299.3 thousands individuals while occupied is 273.9 (1997). The diachronic development of active population and employment in the past few years is increasing. The 38.7% occupied work in the primary sector, the 17.4% in the secondary sector and the 43.9% in the tertiary sector.

<u>Current situation of river-basin / aquifer</u>

Climate has been changing; rainfall has been reduced dramatically leading to extensive irrigation by the farmers. Agriculture relies on river Pinios which the deposits reduce year per year. Concerning water table levels they have been constantly lowering due to overexploitation by private drillings. Framers digging deeper and deeper to find water a fact that leads to salinization mainly in the eastern parts. (Figure14)

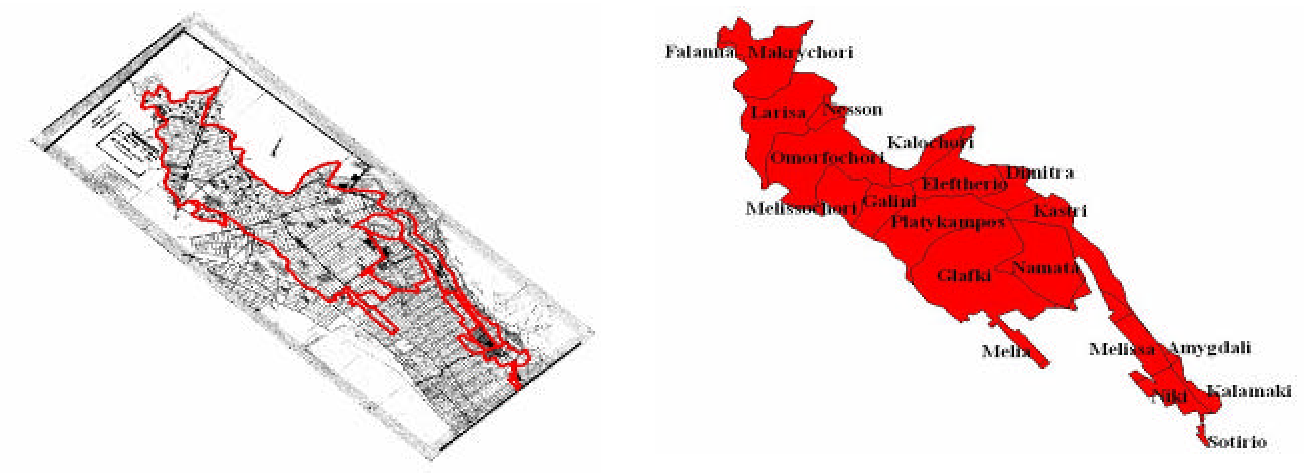


Figure 14: *Current situation river-basin Pinios*

<u>Future perspective</u>

Restructure of cultivation and shift towards less water demanding crops due to high occurrence of drought events. Change of irrigation practices. Efforts in order to develop environmental-conscious farmers through educational programs. Efficient management of available water resources.

<u>Conflicts</u>

Last years conflicts have been arisen between prefectures as concern water special where rivers are transboundary.

<u>Role / weight of principal actors</u>

Coordination and promotion by the government and the prefectures of action plan and strategies are aiming to provide solution with the active participation of municipalities and farmers.

<u>What can PLEIADeS contribute?</u>

PLEIADeS could provide information, expertise, suggestions but the effectiveness of these actions relies on the active participation and constructive cooperation between farmers and local actors.

3.4.5 Gediz (Turkey)

Gediz is a closing basin with little new water available for allocation. Water scarcity is due basically to competition for water among various uses and water pollution although the basin experiences droughts from time to time. It is not, however, a mature basin, in the sense that the institutional set-up is not yet fully developed. Both surface and groundwater use are largely unregulated, and groundwater extraction is growing rapidly in response to urban and industrial demand. There is no functional system of allocating rights to either surface or ground water. The most serious current problem, however, is deteriorating water quality in the Gediz and its tributaries resulting from urban and industrial wastewater discharges and agricultural return flows.

Geographical location and political context

Gediz River Basin is located in western Anatolia in the Aegean region., neighboring the city of Izmir. It is located between N: 38°04’ - 39°13’ and E:26°42’- 29°45’. It ranks as the second largest basin in the region with its drainage area of 18 000 km^2 (2.3% of the total surface area of Turkey). It has a population of 1,700,000. Water allocation is realized by the State Hydraulic Works Authority (DSI). Within the context of irrigated agriculture, 13 Irrigation Associations perform operations and maintenance duties over a territorial extension of about 110 000 ha. Yet, there are serious institutional, legal, social and economic drawbacks which enhance water allocation and water pollution problems.

The largest user of water has been irrigated agriculture, originally deriving from small run-of-the-river diversions from the Gediz and its tributaries dating back some 3000 years. Since 1945, the developments of large-scale systems and groundwater exploitation have transformed irrigated agriculture. The first investments in modern irrigated agriculture began in 1945 with the construction of two large regulators (Adala and Emiralem) to tap the flow of the Gediz River (Figure 16). In the 1960s, a second set of investments were made that included the construction of Demirkopru Reservoir, a third regulator at Ahmetli, and the regulation of the natural lake of Gol Marmara. The final developments took place in the Alasehir valley with the construction of two small reservoirs. The predominant crops are cotton (50%), grapes (35%), maize, fruit orchards, and vegetables. The Basin is currently caught up in a very dynamic period of reassessment and change which began with the onset of the drought in 1989. When the drought struck, irrigation issues in the peak summer season were reduced sharply, return flows diminished, and, as a consequence, water quality in the lower third of the Basin deteriorated.

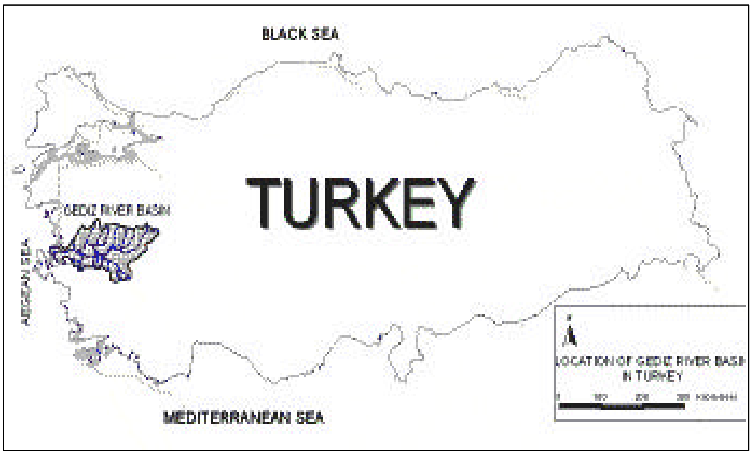


Figure 15: Location of Gediz River Basin in Turkey.

Historical development

Gediz River was known as Hermus in ancient times. Evidence had been found of human activity in the Hermus River plains as early as the Palaeolithic period (ca. 50,000 B.C.). Frigians arrived in western Anatolia via Trace Region and straits and founded city centers in the area. Later, they settled in and around Kütahya (Kotyaeion) and Gediz (Kadoi). The Hermus River supplied the cities with drinking water. After the Frigians, the Lidian’s reigned in the region. The capital of Lidians was Sardes, located in Salihli, Manisa. The Lidian Civilization is known as the first civilization that invented/coined/pressed money. One of the 12 ancient towns of the Greeks is “Temnos” in the muntainous region above Foça (Phocaeans) and Izmir (Smyrnaeans). Its autonomous bronze coinage began in the IV century B.C. and continued till the late Roman Imperial age, followed by the Pergamene Kingdom in III. Century B.C.

Current situation of people

The main income in the Menemen area is agriculture. The rate of literacy is high although the level of education is primary school. Most towns have good infrastructure for roads and sewerage yet with no treatment plants. Drinkable water usually comes from deep wells because of groundwater pollution. Menemen plain is currently closed to further groundwater extraction. Farmers are not sufficiently aware of irrigation management, efficiency and water pollution problems and consider these issues as the responsibility of the government.

Current situation of river-basin / aquifer

Irrigation currently uses a large share (83%) of the surface water resources (660 million m3) of the basin. Hydropower generation has no priority of its own and uses only water that is released for irrigation. Groundwater supplies account for roughly a quarter of basin water use, of which about 16 percent is for irrigation, and the remainder for urban and industrial use. Irrigation use of groundwater is largely static or declining as less-water intensive crops replace cotton.

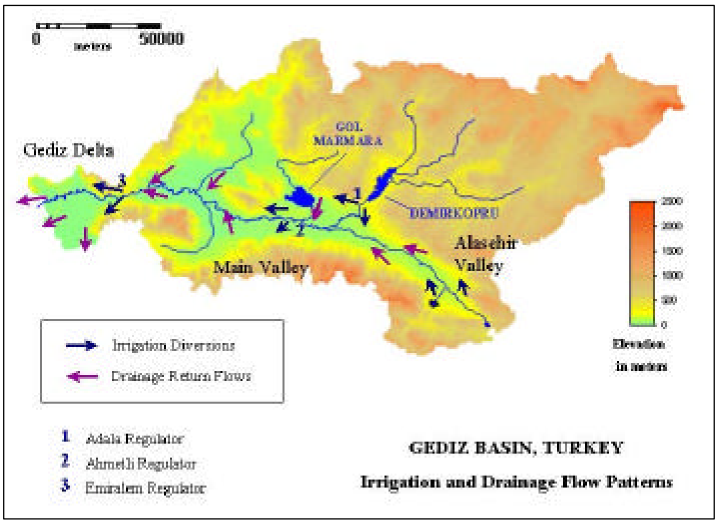


Figure 16*: Irrigation and drainage flow patterns, Gediz basin.*

Future perspective

A BAU (business as usual) scenario for future management of the basin would have chaotic effects. The urgent needs cover: (a) the need for a unified coordinating mechanism for allocating water among irrigation, urban demand, industrial requirements and environmental protection to replace existing bilateral processes; (b) the continuing struggle between older long-established institutions dealing with water resource development and water allocation, and emerging institutions concerned primarily with water quality and environmental issues;(c) the need to represent and protect the interests of certain water users, such as the Gediz delta ecology and the Irrigation Associations; (d) the need for clear rules assigning responsibility for setting water quality and quantity standards and monitoring actual conditions.

Conflicts

The major conflict in the basin is the competition among water users due to water scarcity, water pollution and mainly water allocation deficiencies on the national authorities' part. In essence, there are basically constraints towards achieving objectives of the basin management. Institutional evolution is slow in comparison to rapid evolution in basin key problems. Legislation used in current management practices is too old and cannot meet current demands.

Role/ weight of principal actors

The main actors in basin management are the Ministry of Environment & Foresty, DSI, irrigation associations and local governments. DSI is responsible for supplying the irrigation water, whereas operations and maintenance responsibilities are carried out by the 13 irrigation associations in the basin.

What can PLEIADeS contribute?

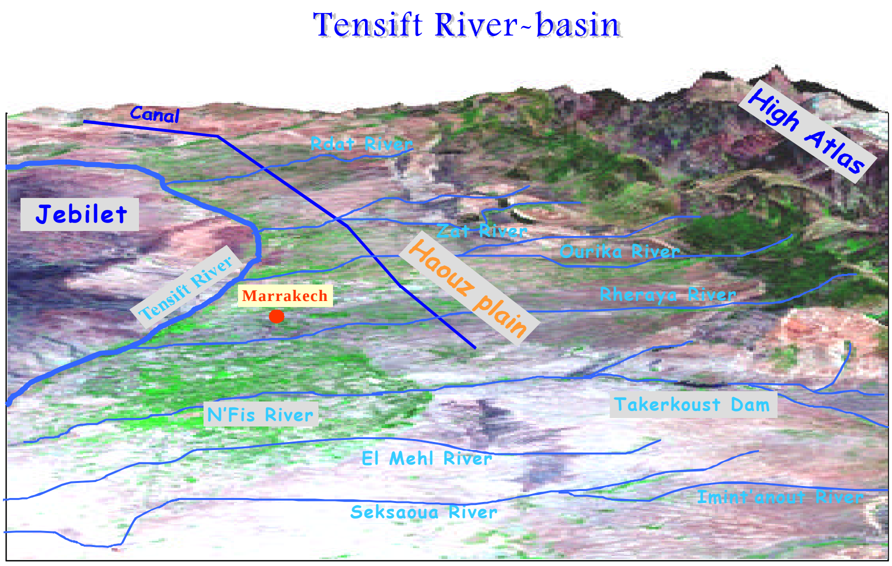
The project can provide feasible assessments of crop water demand especially when regular in-situ measurements are available. The process of participation has just begun to tackle the challenges of high variability of rainfall patterns (increasing due to climate change), the conservative nature of farmers in adapting new technologies, and the lack of proper control and recording within the current irrigation system on who uses how much water. PLEIADes can provide a useful tool to support this process.

3.4.6 Tensift (Morocco)

High productivity with large subsidies in a semiarid region irrigated both with surface water and groundwater. Measures to control excessive pumping have failed to detain the rapid decline in water table. Continuation of the same policies will exacerbate a decline in agricultural activity and severe economic and environmental damages.

<u>Geographical location and political context</u>

The Haouz plain located in the Tensift watershed, in the centre west of morocco (Fig. 17), is a large irrigated area (146 000 ha) over thick and good quality soils around the city of Marrakesh in the semi-arid part. The plain is surrounded by the northern 'Jbilet' hills and the southern High-Atlas mountain range. The High-Atlas culminates up to 4000 m above sea at the Toubkal summit, the highest of North Africa. The Atlas range is indeed the region's water bank, supplying several big irrigated areas in the plain. Dams collect and store water from mountain wadis; it is distributed by ORMVAH (Office Régional de Mise en Valeur Agricole du Haouz) a public organisation through a network of concrete canals to the more recent farms, whereas traditional systems still coexist. Additional quantities are mobilised through direct pumping in the groundwater at the farm level, some being uncontrolled. This agriculture - highly productive when compared to the rain fed one - is using around 85% of available freshwater.



<u>Historical development</u>

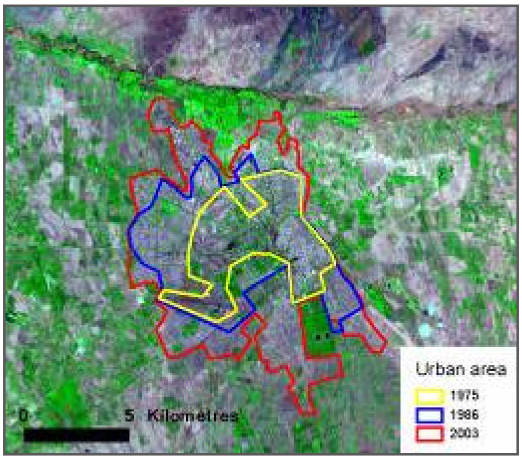
The first occupants of the Haouz plain were Almoravides, which has created Marrakech in 1071. It's under their reign that was built the first khettaras (underground canal). After them the Almohades were ensured the control of the mountain tribes installed throughout piedmont of the High Atlas. It is the alliance with these tribes which will enable them to pass from a policy based on the exploitation of groundwater to the development of an hydro-agricultural plan, which considers not only the derivation of the rivers, but also the transfer of the hydraulic resources from an area to another. At the beginning of the twentieth century, French protectorate introduces a new technique of irrigation: dam, and modifies the rules of management: appearance of a new actor, the colonist. The construction of the Lalla Takerkoust dam in 1935 allows regularizing the contributions of water over all the year. After the independence of Morocco, the Moroccan State continues the policy of great hydraulics (GH) with for principal objective the irrigation of the million hectares in the year 2000. Today, all the components of this hydraulic system, whose installation spreads out on more than eight centuries, are always in force. The innovations are often superimposed with the pre-existing structures.

<u>Current situation of people</u>

The farms are characterized by the prevalence of the micro property and the space dispersion of parcels. A great number of families have a small lands (under 5 ha) and a small number of families have most of the land with farms greater than 20 ha. With the drought the small farmers are constrained to sell their lands.

Current situation of river-basin / aquifer

The region is characterised by scarcity and space-temporal heterogeneity of the rains distribution. In the plain about 85% of available water is used by agriculture. Major irrigated vegetation types include olive, oranges and wheat. Due to the expansion of the main city (i.e. Marrakech, which extents of about 35 % during the past 30 years) as well as of the surface of irrigated zones (increase of about 40% during the past 30 years), water resource is facing an enormous pressure. This has been translated to an over-exploitation of groundwater (the groundwater level decrease for about one meter by year and increased water demand for agriculture and tourism.



Urban and tourist development of Marrakech and its area

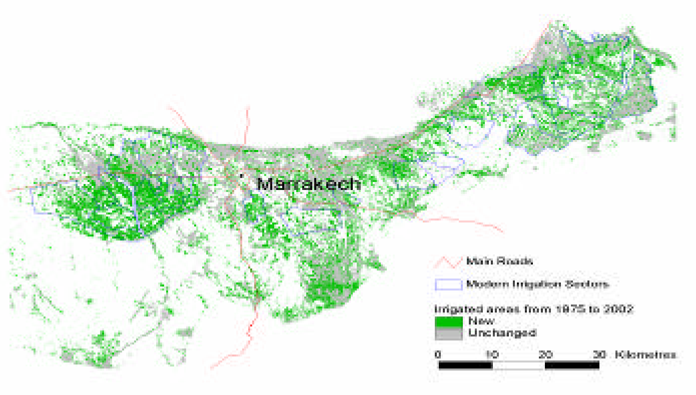


Figure 17

Future perspective

With the increasing demand of other sectors (particularly tourism and urban development), the efficiency of irrigation is now scrutinised and less consuming crops and irrigation techniques are developed. Simultaneously, water authorities are conscious of the need for a better management of existing resources (or even scarcer in the scenario of aridification of the climate) and to move from the current simple offer-based to more advanced demand-driven water distribution schemes.

Conflicts

Since 2002, water use has expanded to recreation activities (Aquatic Park, golf…) at the expense of agriculture. This creates a situation of conflict between different water users in the region.

Role / weight of principal actors

The hydraulic basin agency of Tensift (ABHT) has the role of evaluating, planning, developing and managing the water resources.
The ORMVAH has the responsibility for the management of all the water resources for irrigation as well as systems and equipment of irrigation. ORMVAH, together with local farmer associations, is in charge of the dam water distribution. At the beginning of the agricultural campaign, they decide the periods for several irrigation rounds, which are regularly distributed from December to May.

What can PLEIADeS contribute?

To guarantee the durability of water resources of a basin, it is necessary that the offer and demand of water are balanced for a Sustainable development. PLEIADeS will contribute to management of the irrigation, by: estimation of crop water demand and quantification of evapotranspiration; development and use of SPIDER to improve efficiency of irrigation and contribute to stabilize groundwater level.

3.4.7 Ica (Peru)

> High productivity without subsidies in a hyper-arid region irrigated completely with groundwater. Measures to control excessive pumping began to be implemented by the local groundwater user associations. This association expects to stop the decline in the water table and avoid risking the important agro-exportation in Ica, as well as water supplies for domestic use, other economic activities, and environmental needs.

<u>Geographical location</u>

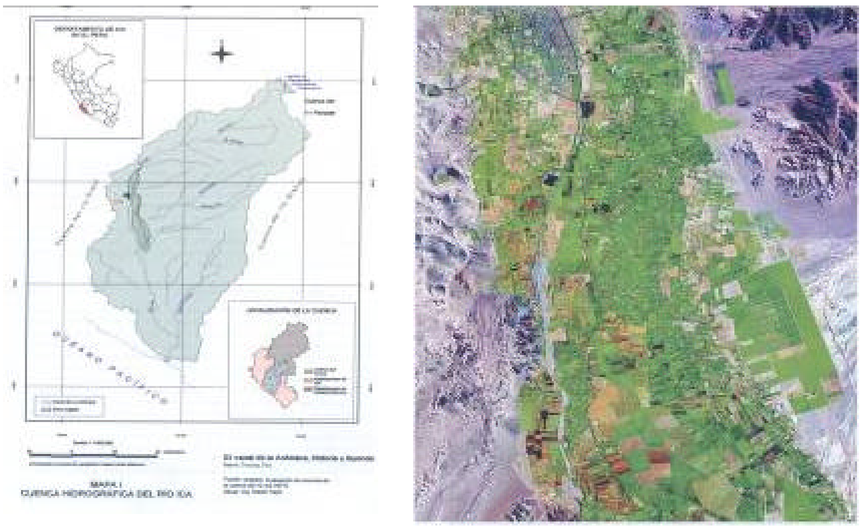


Figure 18. Location of Ica river-basin (left) and view from satellite (right)

<u>Historical development</u>

The city of Ica is the capital of the Ica Region in southern Peru, 300 km from Lima. It was founded in 1563 by Spanish conquistador Gerónimo Luis de Cabrera. As of 2005, it had an estimated population of about 230,000. However, with almost no rain during the year, Ica´s traditional agriculture relies on seasonal water flowing during the months of December to March from the Andean mountains. In Inca times channels like the Achirana, still used today, were built. Modern irrigation developments during the past century improved water supplies and cotton became the main crop. Lately groundwater is the main source of water for the fast growing agro-exportation local business with asparagus, grapes, avocados, citrus, peppers, onions, artichokes, and others new crops.*(Figure 20)*

Figure 19: Sand dunes with natural vegetation (top);
asparagus field (bottom)

<u>Current situation of people</u>

Residents from low income settlements around the city of Ica provide labor for mid to large size farms. Despite the increasing mean local income and lower levels of unemployment, a small number of families own most of the land causing small farmers to disappear and therefore expanding the social gap between the small elite who benefit from the agribusiness and the people who pay for the environmental and social costs. A large number of seasonal workers from out of the Region, mainly from the Andean zones also work in Ica.

Figure 20. Ica landscape: strong sun, dunes, and cultivated land.

<u>Current situation of river-basin / aquifer</u>

Ica basin encompasses 7187.50 km^2 extended over the Ica and Huancavelica Regions, with elevations from 4,500 m to the sea level, along a 220 km profile. The main aquifer, Ica-Villacurí, reaches about 1,000 km^2, with water recharge mainly from the Ica river. Total water extraction is 500 Mm3/year, collected from 1,200 wells to attend 160 km^2 of exportation crops using near 350 Mm^3/year. The power expenses (without subsidies) are in between US $350 and 550/hectare, using drip irrigation.

<u>Future perspective and conflicts</u>

Present trends show increasing land use and value (5,000 – 13,000 US $/ha, during the last years); as well as higher water price (cost for drilling a well is about US $150,000). Corruption, illegal land transactions and false water permits are common and increasing. Immigrants from Andean regions settling in the region looking for better working conditions are increasing as well; and watertable level going down (up to 1m/year), also water quality decreases due to salt accumulation. This scenario will worsen with climate change predictions, resulting in serious local water problems and potential conflicts in the near future.

<u>Role / weight of principal actors</u>

Agricultural water control is carried out by the Regional Government, and since October 2005 the private Ica Valley Groundwater Users Commission (CRASVI) was officially recognized to organize and supervise well drilling to avoid overexploitation by the agroindustry. New national legislation contributes to the efficient use of water and civil society is presently more involved in water rights.

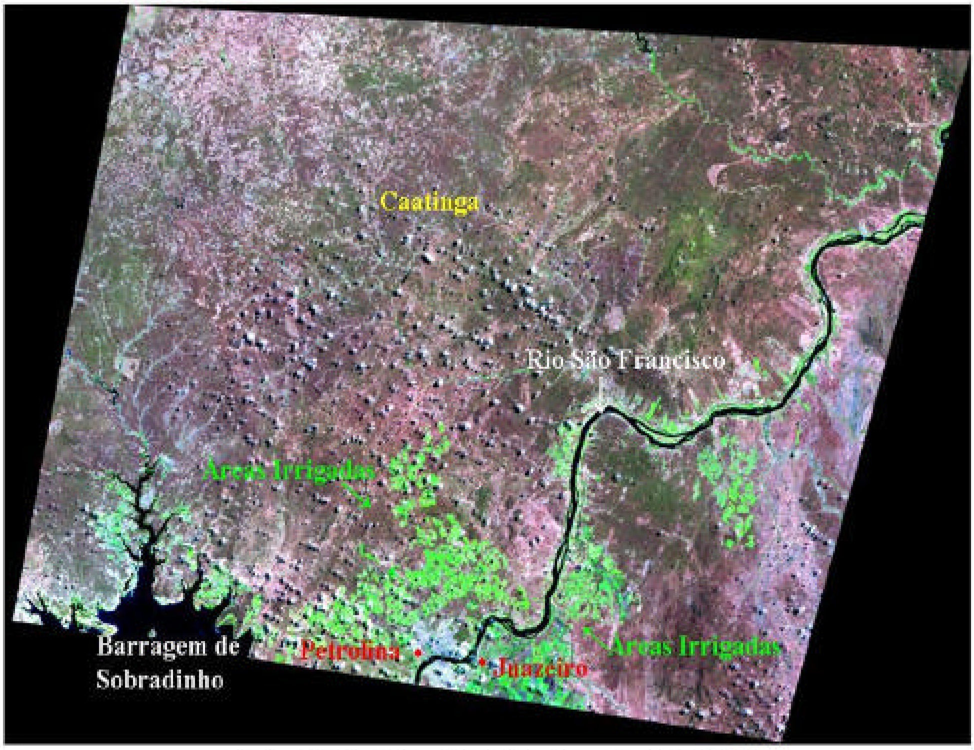
<u>What can PLEIADeS contribute?</u>

PLEIADeS is working now to learn about water use by asparagus and improve its efficiency. Asparagus is at present the second main crop in Ica with 6500 ha intensively cultivated year round, and it seems there is room to save water without compromising production volume and quality. PLEIADeS-Peru pilot area is located in the Don Ernesto farm, belonging to Agrícola Chapi, located in the Santiago District, Pampa de los Castillos Sector, 20 km south of the city of Ica. The more water saved in Don Ernesto farm will translate to more water reserves for the future which will benefit the stakeholders whom rely on the Ica-Villacuri aquifer.

3.4.8 São Francisco (Brazil)

A combination of a large number of small agricultural plots and a smaller number of medium to large entrepreneurial farmers mainly with trickle and micro-sprinkling irrigation. Water use performance needs to be improved. Recent change to labour-intensive wine grape production in the region is expected to create new jobs.

<u>Geographical location</u>



Visão Geral do Perímetro Irrigado Nilo Coelho- Imagem LandSat 05-09-2008

Figure 21. The Nilo Coelho irrigation scheme and the Sobradino dam as seen by Landsat 5.

<u>Historical development</u>

Lower-middle São Francisco used to be an area where farmers historically grew onions and tomatoes (under low technology resources) and raised goats and sheep. There was a race of (woolless) sheep typical from the region. The onion market used to be quite unpredictable so that sudden great profits, as well as sudden bankruptcies were not uncommon.
Since approximately 30 years ago, the scenario started changing towards fruits crops, first irrigated by sprinklers and later by localized irrigation.

<u>Current situation of people</u>

The whole of Nilo Coelho scheme comprises a total of 20,443 ha of irrigable land of which 18,375 ha are effectively being irrigated. 32 farms are considered large enterprises (over 50 ha each); 79 farms are medium enterprises (21 to 50 ha); 55 are small enterprises (12 to 20 ha); and 2,051 plots are small irrigation plots of less than 12 ha (average of 6 ha). The (whole) São Francisco Valley is responsible for 30% of the value of fruit exports of Brazil and 95% the value of grape export.
Small farmers sell their produces either to large farmers or to a cooperative organization that functions in the area. Grape production employs 2 to 3 people per hectare, of which usually more than 60% are fixed labor. That creates a favorable scenario for seasonal and non-seasonal workers.

Current situation of river-basin / aquifer

The lower-middle *São Francisco* is a semi-arid climate, with an average annual precipitation of around 500 mm, badly distributed along the year. The *São Francisco* River is currently undergoing a “National Program of Re-vitalization” in an effort to reclaim several parts of the river and its tributaries, in which considerable damages (such as mineral and organic pollution, erosion, siltation, among others) are occurring.

Future perspective

At the same time, the irrigated area in the valley is expanding and reached some 3.3 million ha now, as compared with less than 3 million 10 years ago. Therefore, it becomes essential to be concerned about the risk of deterioration and over-exploitation, as well as trying to improve water productivity.
From the socio-economic performance viewpoint, the lower-middle São Francisco, where Nilo Coelho is located, presents a promising outlook, as the market is expanding, economy is progressing and the job opportunities are growing.

Role / weight of principal actors

Government had a fundamental role at the very beginning, when CODEVASF (Companhia de Desenvolvimento dos Vales do São Francisco e do Paranaiba) contributed to build most of the infrastructure (pumping stations, canals, service roads, schools, housing facilities etc). After creation of the “Irrigation District” (some 15 to 20 years ago), the responsibility of management was transferred to the District manager and major decisions taken by its Council, with a minimal supervision by CODEVASF.
From that point on, most of the management strategies are made on a private basis, between the District and water users (large and small ones).

What can PLEIADeS contribute?

The most important point for PLEIADeS contribution would be in improving irrigation water management and productivity. It would be more effective if that could be done through an Earth Observation approach because that would allow for upscaling to more schemes in the São Francisco basin (and even new basins), beyond the present pilot area.

3.4.9 Sonora (Mexico)

High productivity with large subsidies in a semiarid region irrigated completely with groundwater. Measures to control excessive pumping have failed to detain the rapid decline in the water table and sea water intrusion. Ongoing of the same policies, will exacerbate a decline in agricultural activity with economic and environmental damages

Geographical location and political context

Costa de Hermosillo is located in the lower part of the Río Sonora Basin in the semiarid northwest Mexico (Fig. 23). Placed between the city of Hermosillo (to the west) and the Gulf of California (to the East) the irrigation district encompasses an area of 169,593 ha. The actual total irrigated area is about 30,000 ha, although, on some years, it was as high as 70,000 ha. This is a highly technified and productive area where the main crops are wheat, chickpeas, corn, grapes, citrics and pecans,
Irrigation water is supplied by an overexploited aquifer with an actual authorized extraction of 350 hm^3 even though in some years extraction reached 1150 hm^3. This over extraction has led to a situation where the freatic level is 70 m below sea level, in some places and saline water intrusion has advanced up to 20 km inland. Administration of the District is in charge of the Civil Water Users Association (ASUDIR) and law enforcement (extractions) is foreseen by the National Water Commission (CNA).

Historical development

Costa de Hermosillo was first populated by Seris (fishing & small-scale agriculture). In 1700, Spanish funded, to the West, small towns inhabited by Seris, Tepocas and Low Pimas, which gave origin to the city of Hermosillo. In 1844 the Hacienda de la Costa Rica was funded. This was the first colonial settlement in Costa de Hermosillo. By 1920, the first Italian immigrants began to arrive. With their agricultural knowledge and technology, they managed to give a great impulse to Costa de Hermosillo, by 1930. In 1941 the Irrigation District No. 51 was created and a new transformation of the region began. This was consolidated with the built of the Abelardo L. Rodríguez dam.

Figure 22: *Geographical location and main features of the Río Sonora Watershed and the Costa de Hermosillo Irrigation District.*

Current situation of people

A small number of families have most of the land & power; colonos & ejidatarios have almost disappeared, social gap widening between small elite (who reap the benefits from their agribusiness) & rest of people (who pay for the environmental & social costs). There is large number of seasonal workers from out-of-state.

Current situation of river-basin / aquifer

Climate has always been arid and agriculture relies on groundwater for irrigation which has been heavily overexploited. This has lead to salinization and sea-water intrusion that has made unviable agriculture in near-cost areas and higher extraction cost in the rest of the area due to lower water levels in the aquifer. Agroindustry has been operating at high intensity for more than 30 years and the large commercial farms are now producing for exportation, moving away from traditional crops like wheat and corn to high-value crops like grapes, fruit trees, leading to an increase in crop water requirements.

Future perspective

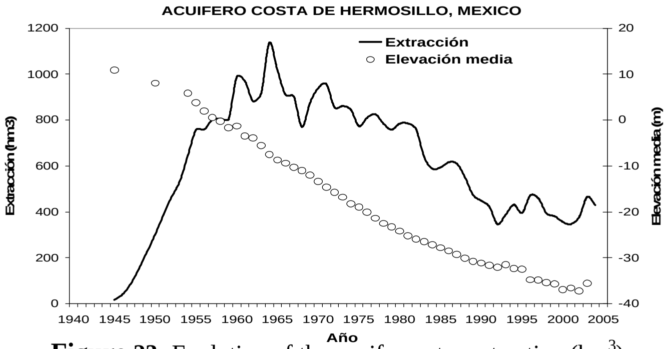


Figure 23: Evolution of the aquifer water extraction (hm^3) and elevation (masl) of the water level in the aquifer for the last 60 **years.**

The worst scenario is to continue as usual (nothing changes), clearly leading to environmental and social disaster, while rich elite producers will move away to other areas as soon as profits go down. The estimated time left for the aquifer, if things don't change, is 10-20 years but this can be aggravated by climate change (there has been a severe drought for past the 10 years). Best case scenario would be to stop the declining of the water table declining. This would require to reduce the extractions by using more efficient irrigation systems, real estimates of crop water consumption, enforcement of the law (to comply with the authorized extractions) and changes in the law (to reduce the authorized amount of extraction).

Conflicts

There seems not to be major open conflicts between managers at all government levels; even though, the lack of reliable information and strict application of laws and rules, creates an advantageous situation for "small owners". These don't live in the country where the land is, they rather prefer to live in the nearby city of Hermosillo, hence they are not very much aware or involved in the solution of social conflicts in the area. In Costa de Hermosillo more than 32 ethnic groups, coming mainly from the South of the Country, live together. They constitute the main labor force in the region. Because of their education and habits, problems of social marginalization, crime and drug abuse, among others, are created. Seris were the only ethnic minority displaced by the first settlers.

Role / weight of principal actors

The National Water Commission (CNA) is the part from the federal government dedicated to elaborate and execute the hydraulic development plan, the normative and to build the strategic infrastructure. In the second level are the Watershed Councils which deal with regional programs and watershed sustainability and coordinate between CNA and the water users. In the case of the Costa de Hermosillo, the Technical Committee for Groundwater (COTAS), formulates, promotes and oversees the programs and actions to recover, stabilize and preserve the aquifer. The Water Users Association charges fees and keeps track of maintaining the infrastructure of the Irrigation District. Most of the water wells doesn't have any kind of measuring device and the users are reticent to allow access to their farms making it difficult to estimate the real water extraction.

What can PLEIADeS contribute?

Crop water demand and crop water use are key factors to improve irrigation efficiency. In this sense PLEIADeS could assist in making quasi real time estimations of water consumption at farm level and water extraction at farm and District level leading to improve irrigation efficiency and stabilization of aquifer levels if the savings are really used to extract less water. This, of course, will depend on who and how uses SPIDER. If SPIDER improves efficiency of agribusiness, the saved water could be used for more crops, but can of course, not be used and help sustainability of the aquifer

The legal instruments to stabilize the aquifer are there. Most of the users, and mainly those from the 12 bigger groups, although they know the problem and show a real interest in improving the aquifer situation, don't take any actions that could affect their economic interests and always try to take advantage of any legal or administrative gap to make an excessive use of the aquifer. Hence, PLEIADeS can help to raise their awareness, so they can at least make informed decisions, by showing them viable alternatives. One other way is to make integrated analysis of cost of the agro industry, by internalizing the cost that is now external (environmental, social). Side remark: aquifer / irrigation almost totally decoupled from river-basin.

3.4.10 Tremonton (U.S.A.)

Medium to high productivity of irrigated crops grown to support the dairy industry in a semiarid region irrigated completely with surface river water. Water conflicts have been solved through interstate compacts and agreements between the main water users. More storage capacity might be needed with changing climate.

Geographical location and political context

The Bear River Canal Company is located in northern Utah, USA approximately 30 Km west of Logan, UT. The town of Tremonton is within the irrigated area served by the main canal. The irrigation water is diverted from the Bear River through a diversion dam that forms the Cutler reservoir (Figure 1). The irrigated area comprises approximately 28000 hectares, mostly under furrow and border surface irrigation. The soils are mostly well drained loams and sandy loams with higher sand content closer to the river. The climate is semi-arid with a yearly precipitation amount of approximately 440 mm, mostly in the form of winter snow and spring rain. The Bear River headwaters are in the high Uinta Mountains of northern Utah with peaks ranging from 3400 to 4100 m in elevation that accumulate a heavy snow pack every winter. The spring runoff is partially stored in the Bear Lake, a natural lake that historically has received very high floodwaters from the Bear in the spring, now augmented by a canal to store from and release water to the river. The storage and releases are controlled by the PacifiCorp that stores water for hydropower generation and irrigated agriculture downstream. The Bear River flows through Wyoming and Idaho prior to re-entering northern Utah. Several diversions for irrigation occur upstream prior to the diversion by the Bear River Canal Company (Figure 25) which is close to the tail end of the system.

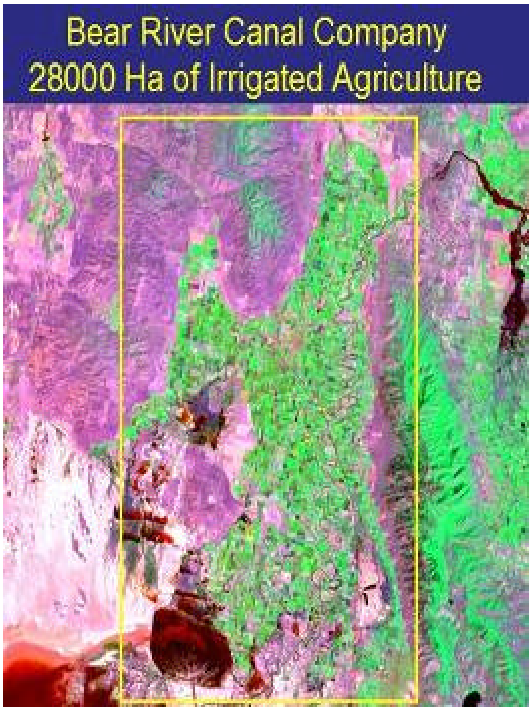


Figure 24 The Bear River Canal Company Irrigated Area Detail of the Diversion Dam and Main Canal

Historical development

The irrigated project was developed by a sugar production company (from sugar beets) in the beginning of the twentieth century and has one of the oldest water rights on the Bear River. It is currently managed by the Bear River Canal Co. Additional history of the canal company and the Bear River can be found at:
http://www.ci.slc.ut.us/utilities/NewsEvents/news2000/news11022000.htm

Current situation of people

The farms and crops mostly support the diary and livestock industry. The main crops produced are alfalfa, corn, pasture and small grains (winter and spring wheat).

Future perspective

The Bear River water is almost entirely adjudicated. Winter snowpack accumulation is the main source of water. Climate models predict a higher amount of precipitation with a larger percentage in the form or rain. It might be necessary to build additional dams to impound this water before it reaches the Great Salt Lake.

Conflicts

There are presently no serious conflicts within the Bear River system. Most of them were solved by an interstate compact. In the past there has been some conflict in water-short years with the Bear River Bird Refuge, a US Fish and Wildlife facility downstream from the irrigated area and the last user of river water before it enters the Great Salt Lake. An agreement was negotiated on how to manage water under drought years including storage of irrigation water for the canal company in Bear Lake.

Role / weight of principal actors

The Bear River Basin is managed through an intestate compact with an appointed commissioner. Most of the consumptive use results from irrigated agriculture with numerous diversions in all three states the river crosses. In addition to the agricultural stakeholders, there are several municipalities that share this water resource or contribute wastewater to the system.

What can PLEIADeS contribute?

PLEIADeS through the use of SPIDER could provide information on integrated water demand for the irrigated area served by the canal, allowing for the estimation of system efficiencies and potential water savings through improved management strategies.

3.5 Horizontal issues:"Gender matters"

At the beginning of the project a Gender Action Plan (GAP) was drawn up as an 'action' oriented document that set out the gender roadmap that the PLEIADeS partners were advised to follow throughout the 3 years of the project. This was with the ambition to ensure that the project's outputs incorporated a gender perspective through an effective equal opportunities and gender mainstreaming approach.

The philosophy adopted throughout was taken from many studies which (as summarized by Zwarteveen 2006) have shown that:

- ✓ Involving both women and men in integrated water resources initiatives can increase project effectiveness;
- ✓ Using a gender perspective and ensuring women's involvement can support environmental sustainability;
- ✓ Without specific attention to gender issues, projects can reinforce inequalities and even increase imbalances.

The GAP strived to identify the gender issues of relevance to the project. It set out to explain the terminology, the rationale, the strategy and the various actions that it followed throughout the 3 years. To help ensure that the gender actions were pursued, a Gender Working Group was constituted in the first year from amongst the partners. Its composition reflected a careful balance between women and men, technical disciplines, and pilot areas.

Besides describing the role of the Gender Working Group and the role of the Regional Manager, the document outlined in detail the role and tasks of the Gender Focal Point that each Regional Manager had the obligation to appoint at each of the nine pilot zones.

The philosophy of awareness raising and activities promoted in the Gender Action Plan were actively followed throughout the whole duration of the PLEIADeS project through email contact with Regional Managers and the Gender Focal Points; with distribution of 11 Gender Notes outlining various gender actions; and with presentations and discussions at every meeting opportunity. Thus the topics of the GAP were discussed at the WP integration meeting in Madrid, and in Rome and in the Plenary Meetings in Lima and in Izmir with all the partners present. From the first year, partners were urged **to employ positive actions** when engaging researchers; to have women participating in meetings and in making presentations whenever possible, and to invite women to the stakeholder workshops.

The GAP also ensured that inclusive gender approaches were included throughout the development of the workpackages (WPs) and the frameworks. The following were proposed actions within the WPs that contributed towards understanding the gender picture of each river basin:

1. Ensure gender disaggregation of data, e.g. in (WP1)
2. Ensure women's stories and legends are included (WP1, part of D4a)
3. Ensure 'user requirements' has a gender perspective (WP2b)
4. Ensure gender perspective is respected when establishing the sample of end-users, to be trained in using the system, to conduct test runs & evaluation during development phase (WP2g)
5. Include specific gender questions in all questionnaires, e.g. in (WP8a)
6. Ensure gender perspective is respected in the guidelines on irrigation and fertilizer management (WP5)
7. Ensure gender perspective is respected in the guidelines for the application of CBA methods, and in the evaluation of the impacts associated with water use in agriculture (WP6)

Through the WP leader meetings and discussions in Madrid, and in Rome, and through effective gender reviewing, practically all the WPs and frameworks included an angle on gender perspective.

On the other hand having **more women involved in the regional meetings** both at the water management level and at the core and control group level proved more difficult, and although awareness of this fact was raised in the Izmir 3rd Plenary Meeting through interactive gender workshops, the situation did not improve through increase in numbers. However, it must be stated that the women who did participate in the regional stakeholder workshops were determined to be effective, as was proved in some pilot areas. In Caia, Portugal there are 2 women farmers who are IT knowledgeable, (one of them proved very articulate during a filmed interview), whilst in the Gediz, Turkey, although there are no women farmers found in the area under study, there are a high number of women at water management level who were very active in the regional meetings. In Tensift, Morocco and Nurra, Italy also yielded only one woman participant. However, in Morocco, the woman water manager was looking for the right incentives to approach whole families that are running farms in the Tensift basin, and participating in PLEAIDeS gave her that opportunity to go and explain the merits of SPIDER to family run farms. Targeting the whole family was also aptly demonstrated in the Pinios, the Greek pilot area, when a woman farmer, together with her son and daughter showed keen interest in learning SPIDER.

The right time to reap the benefits of the building up of gender awareness throughout the consortium came with the 3rd Plenary Meeting in Izmir. This was the venue that clinched the focus on gender with the regional managers and the partners actively participating in three parallel working sessions on different gender topics. Participants in each session were invited to choose one or more topics from among nine Gender Notes provided by Anna Spiteri. The respective rapporteurs from Portugal, Peru and Morocco presented the following conclusions:

- *Vanja Karadzic*: When discussing the topic of **gender discrimination**, important differences were observed across the different pilots, which had to be considered within the context of respect for the local traditions and culture.
- *Teresa Oré.*: The **gender analysis** demonstrated very positive results had been obtained, with several regional teams paying attention to involve (more) women, even if different levels of success could be noticed. Researching the role of women, within the socio-economic and cultural conditions in the different pilot areas, was important to then suggest actions how to include (more) women in the participatory process.
- *Mounia Benrhanem*: **Water governance** involves the entire water family, not only the decision-makers, and it was therefore important to benchmark across the pilot areas in order to gain insight in new strategies, tools and approaches to address gender issues.

The outcome of these sessions revealed that the **PLEIADeS Gender Action Plan** did achieve its target objective of raising awareness on gender aspects but it is worth to note that this happened not only within, but also outside the Consortium as evidenced from two invitations to present the gender aspect of the project in international meetings:

- During 14-15 March 2009, Anna Spiteri presented the "Gender Action in PLEIADeS" as Invited Speaker in Topic session 1: "Why Gender Mainstreaming in Water Management?" of the Preparatory Conference on "Women & Gender – Ensuring Equal Participation in World Water Forum 5" organized by the Istanbul Technical University, Turkish Women's Water Platform (TWWP), Gender and Water Alliance (GWA) and Women for Water Partnership (WfWP), and,
- In May 2009, Vanja Karadzic presented PLEIADeS Gender strategy at the Side event CSD17 »Women and Solutions for Water Scarcity in Agricultre. Exchange and Learning session», organized by the Women for Water Partnership (WfWP), Dutch Presidency of CSD17, as well as the ministries of Foreign Affairs, Agriculture and of Water, at the UN HQ in New York, US. Presentation was focused on the gender sensitive approach, developed in PLEIADeS, including actions to integrate and honour women's perspective, skills and needs, related to PLEIADeS technology design.

Gender Notes for circulation and discussion during November 2008 / June 2009

Gender Note One	Positive Actions
Gender Note Two	Gender and Technology (Lima)
Gender Note Three	Gender Perspective
Gender Note Four	Participatory Processes and Gender
Gender Note Five	Gender analysis
Gender Note Six	Gender Planning and Tools in Water Sectors
Gender Note Seven	Getting the initiative or project right
Gender Note Eight	Gender Mainstreaming in the Project mid Cycle
Gender Note Nine	Capacity Building
Gender Note Ten	Gender-sensitive monitoring and evaluation indicators
Gender Note Eleven	Guidelines on Inclusive Language

4 Impact and sustainable implementation – “The Future”

Water is a critical issue worldwide and water conflicts are arising in many regions, with available resources diminishing in quantity and quality and the range of uses in competing sectors increasing. Periodic droughts and floods exacerbate conflicts and reveal the increasing vulnerability of water uses. Water for food production represents by far the largest share among all uses, but water demand is still growing with increasing population, especially in non-industrialized countries where it is the very basis of subsistence for large parts of the population. Lack of water can adversely affect the economic and social stability of entire regions.

PLEIADeS has introduced new technologies as tools to assist in irrigation water management to prevent or resolve conflict, offering the information to a wide range of stakeholders at their required space-time resolution in non-academic, non-technical, easy-to-use and intuitive form that encourages participation.

Working directly with key users and the relevant government organisations, including active stakeholder participation and gender mainstreaming, has proven to be a key for successful and sustainable implementation in policy and practice. Core users have clearly endorsed the system and have demonstrated their commitment to make post-project sustainable implementation a political and physical reality.

We define “sustainable implementation” as the implementation of some or all PLEIADeS components in a users’ routine environment in a way that its maintenance, infrastructure, and funding are secured beyond any short-term grant funding. The following elements have been confirmed as **necessary elements of sustainable implementation** (probably in descending order of priority):

- political will (at local, regional, and/or national level);
- people that are interested in using it;
- people who know how to maintain and run it;
- capacity building, training, education;
- infrastructure;
- funding.

During the last project phase, special emphasis has been placed on assessing the potential of sustainable implementation beyond the project lifetime and on developing the corresponding roadmaps. We briefly summarize below the status of user evaluation and perspectives for sustainable implementation in each pilot area.

Portugal
The user at irrigation scheme scale is partner ABCaia. Farmers and further stakeholders have also been involved in the evaluation process. SPIDER was introduced in interactive practice sessions with the latter, while ABCaia has received personal training. Discussions about a joint post-project implementation with the adjacent Spanish area are well under way.

Spain
Junta Ex is the institutional user at regional level and as such, has performed its own evaluation. Collaboration with 2 irrigation users associations has been intensified. Political will and technical capacity for post-project implementation are clearly manifest. Practical details of cross-border implementation are being discussed with the Portuguese neighbours.

Italy
The user at irrigation scheme scale is the Consorzio di Bonifica della Nurra (participating as subcontractor of partner INEA). Also several large commercial farms have been actively participating in the evaluation. There is political will, user interest, and technical capacity for post-project implementation.

Greece
The user-related work has started to catch up, as the local data and information is now becoming available on SPIDER. Consequently, the core user group meetings have recently been resumed in order to provide information and training.

Turkey
The user at irrigation scheme scale is the Menemen Left Bank Irrigation Association. As the local data and information has now become available on SPIDER, training and practice sessions are now being advanced.

Morocco
The user at irrigation scheme scale is the Haouz plain regional irrigation district office ORMVAH, which has been actively collaborating throughout the project. Evaluation has also been preformed by the river-basin scale user ABHT (Agence du Bassin Hydrographique du Tensift) whose interest has grown strongly in the process. There is political will at local level and technical capacity for post-project implementation.

Mexico
The user at irrigation scheme scale is the users association of the Costa de Hermosillo irrigation district, which until very recently has shown only moderate interest in active collaboration. More interest was coming from the river-basin authority and one of the major commercial farms in the area. During the past six months, the situation has changed dramatically and the irrigation users association has now set out to implement the system, while still sorting out some practical details.

Peru
The local user actively involved in evaluation is the commercial farm Agrícola Chapi. The creation of the aquifer-wide irrigation users association is very recent. They have expressed very high interest, but recommended to start with collaboration at farm enterprise level. Agrícola Chapi has been affected by the economic situation and therefore reduced their project activity for some time. This has now been overcome, so that the way to post-project implementation is becoming clear.

Brazil
After the very late start of the work (due to administrative difficulties), the Brazilian team has been catching up rapidly. Generation of products for upload to SPIDER has been achieved only recently. Consequently, there was no opportunity so far for user evaluation.

USA
A basic set of data for the Bear River irrigation district has been uploaded on SPIDER and an online demonstration was presented at the 3rd Plenary Meeting. User evaluation is now following although not initially planned (non-budgeted partner). This is independent of the project end, since the funding comes from other sources.

Annex A. Main publications

The project has produced so far

4 chapters in books;
55 publications in scientific journals;
41 publications in conference proceedings;
51 oral presentations in conferences (many with short abstract);
15 poster presentations;
5 Ph.D. theses (3 more to come);
3 other publications (reports of limited distribution).

The following gives a list of the scientific journal publications only.
For full list of publications, see Periodic Activity Report Period 3 (Annex A).

Publications in scientific journals:

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