ICARUS

IWRM for Climate Change Adaptation in Rural Social Ecosystems in Southern Europe

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The intent of the research reports is to provide relevant information and to stimulate discussion of those having an interest in integrated water resource management (IWRM). The results and conclusions of all reports produced under the IWRM-Net Funding Initiative will be disseminated across the network to the appropriate audience (river basin managers, policy-makers, research funding bodies, universities, industries, and other stakeholders at all levels), and on the general IWRM-Net website (http://www.iwrm-net.eu).

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Contents

1. Introduction

Water resources management presents significant challenges for the economic and social development of southern Europe. Considered frequently as a common good, water is essential to life and to numerous human activities, and suffers their negative impacts. In the Mediterranean region, irrigated agriculture, intense urbanisation, and tourism are increasing their demands for water, requiring therefore important efforts to find new strategies to better manage this scarce resource.

Following the goals of the Water Framework Directive (WFD), in Europe new methods for more efficient water management are needed to meet local needs. The ICARUS project focuses in particular on the need to increase the efficiency of water management under scenarios of climate change and increased demand. The pressure caused by these scenarios threatens the agro-industrial employment, can reduce food security, brings damage to aquatic ecosystems, and increases desertification and loss of biodiversity. In short, it obliges to make changes in models of water management.

Those problems require the implementation of a holistic analytical approach for water’s integrated management approach. In order to implement such approach, the combined socio-economic and ecologic components of our territories should be analysed focusing on their interrelated dynamics. A vast literature has developed over recent years upon the concept of social-ecological systems, or in short, socio-eco-systems, which can be defined as complex adaptive systems where social and biophysical agents are interacting at multiple temporal and spatial scales.

The ICARUS project aimed at developing suggestions for policy-makers for increasing the efficiency of water use in agriculture by first analysing and understanding the biophysical (availability of water resources), socio-economic (demographics, employment, land-use, and competition for water use), and institutional (the Water Framework Directive, agricultural and environmental policies, territorial planning policies and actors) dimensions of sustainable water management and then by identifying innovative adaptation strategies, practices and tools for saving water in irrigated production systems, which could be disseminated also in other Mediterranean countries. Focusing on three case studies in Italy, Spain and Portugal, each facing its own challenges, the project developed and tested a decision support method and tool to integrate the management of supply and demand for water resources in the context of global changes and in the frame of an integrated and participatory approach, as an operational solution for mainstreaming climate change into policies.

ICARUS aims at supporting the implementation of the WFD by promoting transboundary exchange of experiences, by broadening the range of methods and tools available to water managers. The project evaluates the methods of different models and approaches, tries to enhance their usability and to integrate scenarios, which may give more detailed information of the impact of climate change.

1.1 THE PROJECT IN BRIEF

The specific objectives of the project ICARUS are:

- To understand the processes of socio-economic change in agriculture and their impacts in water demand and water availability changes.
- To contribute for better and scientifically sound water governance through the understanding of the policy, legal and institutional frameworks in which decisions regarding water management take place.
- To contribute for the involvement of key water management stakeholders in the water management decision-making processes.
- To develop and test decision support methods and tools to integrate management of supply and demand for water resources in the context of global changes and in the frame of an integrated participatory approach.
- To propose the introduction of the climate change perspective in the practice of Integrated Water Resources Management, via the adoption of climate change (CC) adaptation strategies within the plans for water saving in agriculture.

Summary of key inputs provided by supporting activities:

1. Data collection on existing simulations of CC and socio-economic changes (potential target groups: irrigation communities in Italy, Spain, and Portugal)
2. Information on use of scarce water resources (actual and potential) in regions analysed by the project: comparative analysis of agricultural practices for a best water use and relationships of irrigation system users with other sectors (potential target groups: irrigation communities in Italy, Spain, and Portugal; policy-makers)
3. Comparative analysis of water policies and an assessment of the institutional framework in which decisions regarding irrigation management take place (potential target groups: irrigating communities in Italy, Spain, and Portugal)
4. Analysis of the needs of local farmers in terms of water consumption, and the potential and actual conflicts of water uses (potential target groups: irrigation communities in Italy, Spain, and Portugal)
5. Assessment of the identified adaptation measures and strategies to improve water management and irrigation systems (potential target groups: irrigation communities in Italy, Spain, and Portugal)
6. Integration of all the information as the ground to establish a framework for participatory integrated irrigation management (potential target group: Southern Europe and other Mediterranean countries)
7. Identification and evaluation through a decision support system tool of prospective adaptation strategies for sustainable irrigation management in Southern Europe agriculture (potential target groups: Southern Europe and other Mediterranean countries)

2 Case studies

Figure 1 ICARUS case studies

2.1 SPAIN: THE JÚCAR RIVER BASIN (JRB)

The basin of the river Júcar is made up of 21,578 km^2 distributed between the autonomous regions of Castilla-La Mancha (the provinces of Albacete and Cuenca) and the Valencian Community (the province of Valencia), in Eastern Spain. This watershed could be divided in four sectors with different physical conditions. The first one, the Serranía de Cuenca, encompasses the northern mountainous area, where headwaters sub-basins of Cabriel and Júcar tributaries are placed. To the South, the second sector, the Plateau of La Mancha, is the western part of the Castilian highlands, a plain or tabular relief, badly drained and recently irrigated with groundwater, which presents several endorheic and semi-endorheic areas. To the East, the third sector is an arc of calcareous mountain ranges -strongly karstified – establishes a transition between the high and low sectors and acts as a groundwater reservoir. Finally, the Low Júcar Valley, known as the

Ribera del Xúquer, is an alluvial plain historically and intensively irrigated, flanked to the coast by two protected wetlands, the Marjal de Corbera and the Albufera of Valencia.

There is also a great contrast, from a socio-economical point of view, between the High and the Low Júcar. Whilst La Ribera del Xúquer is a densely populated area, highly urbanized and industrialized, the highlands of this basin are a rural depressed area, where only the functional axis Albacete-Almansa presents an important economic dynamism. Population density reflects this contrast. It reaches values extremely higher in the Xúquer floodplain - 210 inhab./km^2 in the Ribera Alta and 250 inhab./km^2 in the Ribera Baixa- if we compare them with the rest of the basin: inhab./km^2 in the mountain ranges (Province of Cuenca or Caroig Massif) and 27 inhab./km^2 in Albacete plain.

2.2 ITALY: THE VENICE LAGOON WATERSHED (VLW)

The Venice Lagoon Watershed (VLW) is located in the North Eastern part of Italy and consists of several hydrographical sub-basins discharging into the Venice Lagoon. In the past years nutrient discharge of the VLW has been widely studied because of the critical effect on the eutrophication of the Venice Lagoon and the agricultural land use was identified as one of the main pollution sources. The VLW has a surface area of 2,038 km^2 and consist of 8 main sub-basins (which cover about 90% of the whole VLW area) and 7 minor sub-basins. The average annual volume discharged in to the Venice Lagoon is around 109 millions of m^3. In the northern part of the watershed, groundwater recharges surface water, significantly contributing to the hydraulic and nutrient load discharged into the Venice Lagoon. Moreover, due to intensive land use, the VLW is characterised by a very complex network of irrigation channels, which very often receives also direct sewage discharges. Irrigation is a common practice with different methods and varying efficiency. It is very relevant for determining both the volumes of water flowing across the watershed and the quality, in particular for what concerns the content of nutrients, which may significantly contribute to the eutrophication of the Venice lagoon.

The main challenges that the agriculture of the VLW will face over the coming year are therefore related to the maintenance of profitable farming activities while facing increasing environmental constraints related to unstable and decreasing rainfall, increasing conflicts for water resources and also increasing constraints in terms of environmental protection norms.

2.3 PORTUGAL: THE CENTRAL ALGARVE REGION

Central Algarve is a region where extreme climatic conditions and insufficiently fertile land limit the development of a competitive agriculture. With its long dry and hot season, it is a water-stressed area, with a limited and variable stock of water resources, facing strong environmental vulnerability. In this region, the decrease of water availability can have exponential negative effects on the human population well-being. In fact, in this region, irrigation cannot be seen as a way to increase and improve agricultural productivity. Here irrigation is crucial to ensure agricultural productivity. In the framework of the highest water consumption sector, agriculture activities have strong responsibilities in the water preservation in Portugal. These are dependent on the soil occupation extent. The type of land use, the cultures and the fertilizers and pesticides applied, and the geomorphologic conditions, soil type and climatic conditions. Furthermore, in many cases the agriculture areas are located in areas with soils with high infiltration rates and vulnerability where recharge of aquifers take place, which together with bad practices of irrigation and fertilization, leads to the presence of nitrates and pesticides above the limits in the downstream waters.

3 Methodology

This chapter provides an explanation of the methodology: how data and information were collected, analysed, and interpreted within the framework of the project. Each work package (WP) will be briefly described.

3.1 WP2: SCENARIOS OF CHANGE

Climate, socio-economic, and policy changes are deeply affecting agricultural systems in Southern Europe and, in particular, sustainable patterns of water management. Scenario building is a process of creating possible future events by considering alternative possible outcomes (scenarios). Thus, it does not try to show one exact picture of the future. Instead, it presents consciously several alternative future developments. Consequently, a scope of possible future outcomes is observable. This WP focuses on climate, socio-economic, and land use change scenarios to the year 2025.

We should stress here that scenarios and storylines do not intend to give accurate projections of the future, but merely to indicate potential development directions. They generally draw extreme and separate pictures, whereas a mixture of their elements is what most likely will occur. "What is important afterwards is that these eventualities are debated, and that the necessary choices concerning the future of agriculture and the rural world are as fully informed as possible" (Nowicki *et al.,* 2009:22).

The WP2 report collects data gathered from other European projects, which simulate trends of socio-economic, climate, and land use change. In order to gain a perspective of futures in the case study region (Mediterranean Europe), project partners chose to compare the current situation with IPCC SRES A2 future climate scenarios, socio-economic from the EU SCENES project, and land use change indications from the SCENAR-2020ii study. This choice was dictated primarily by the need to find a common source of data for the three case studies, which then in the report were integrated with information available at the local scale.

SCENES storylines describe in general terms possible evolutions of Europe in the future, up to 2100. For the project, we utilised the mid-term projection for the 2025s (2010-2039). Downscaled data either at river basin or NUTS-2 level is available. SCENAR-2020ii, on the other hand, develops three possible evolutions of EU agricultural policy linked to the international market framework up to 2020. After initial considerations, these latter ones are expected to play a larger role on the Southern European agricultural sector during the project's time scale (2015-30) than climate shifts.

The timeframe is purposefully kept to the medium-term (up to 2025) in order to represent at best a realistic planning decision-making context, in line with farmers' and planners' perspectives and, their priorities.

3.1.1 SOCIO-ECONOMIC SCENARIOS

The SCENES project developed four storylines (Economy First, Fortress Europe, Policy Rules, and Sustainability Eventually), which we relied upon for the ICARUS scenarios (SCENES, 2011).

Economy First (EcF) The economy develops towards globalisation and **liberalisation** so innovations spread but income inequality, immigration and urban sprawl cause social tensions. Urban growth escalated and its development is only restricted by pre-existing frameworks of environmental protection, without any additional measure to encourage natural areas (Lavalle et al, 2011). All energy production alternatives are considered, international consortia are financed to find high-tech alternatives to fossil fuels. Global demand for food and biofuel drives the intensification of agriculture with increasing need for irrigation and new cultivation area. **CAP is weakened, hence,** farms are abandoned where crop production is uneconomic. Slow adoption of water-efficient technologies due to peoples limited income, low water-saving consciousness, more single-person households, increase in tourism and lack in training using new irrigation technologies lead to higher water use. Only the higher water prices dampen this trend. It is economic to treat and re-use irrigation return flows thus this practice also reducing diffuse pollution is adopted. Water ecosystems providing ecological goods and services for economies and society (e.g. tourism) are preserved and improved. Thus WFD changes its conceptual focus from the good ecological status to preserving socio-economically worth ecological services. Pollution load increases due to curtailed infrastructure, poor treatment and intensified agriculture. Poisoning incidents catch the interest of media and public. Scientific findings and public protests are being finally heard. Even if governments and European institutions are weak in EcF they are the last straw after recession and social upheaval in 2040s to start working with NGOs, industries and other representatives of civil society to restore economic prosperity and make ground for social coherence.

Fortress Europe (FoE) The world becomes increasingly unstable due to crises, such as energy, financial and climate crises. This causes unstable situations and an increase in terrorism. As a reaction on this EU countries feel a need for more security. This results for instance in more protectionism. Outside threats strengthens the need for EU cooperation and mutual protection. This in turn strengthens the EU integration and the EU institutions. Due to the increasing strength of EU institutions, the EU manages to ease most conflicts within its borders. Although cooperation is not always easy, the fear of being left outside the EU helps to strengthen the EU and solve problems. The EU implements new EU-wide policies on security issues such as energy, food and immigration. The WFD is changed into a Water Security Framework Directive in which the water supply to populations and food and energy sectors is secured. **The CAP becomes more protectionist and is eventually converted to the Secure Agriculture Policy (SAP) aiming on self-sustainability. Also in other sectors self-sustainability becomes important. This increases the market for EU-produced goods, further increased by market barriers for non-EU** goods and services. Development of new technologies is slow therefore the EU relies on outdated technologies in the first decennium. Increased production, combined with outdated technologies and little attention to environmental consequences causes a strong pressure on domestic natural resources, which leads to severe environmental losses and rising costs of resources. Eventually more efficient techniques become available. The net result is, however, a loss in biodiversity. In the end of the second and third period CC becomes a problem. It leads to EU internal migration, water shortages and conflicts. Conflicts are solved by the strong EU institution. CC also leads to conflicts between resources rich and poor countries, which results in a further increase in the gap between world regions.

Policy Rules (PoR) European governments support a stronger coordination of policies at the European level, driven in part by high energy costs, reduced access to energy supplies, the expectation of CC impacts and increasing demand for water. Over this period the EU struggles to sustain increasing political integration in the face of variable compliance with EU directives, especially the WFD. The European Commission and Parliament are strengthened, the Euro is adopted across the region and more and more policies become harmonized at the European level. This integration process is challenged by sudden, non-linear shifts in the rates of political (compliance with EU directives), climatic (atmospheric warming), and economic (energy and food prices) processes. Policies become less effective in the medium-term because they deal piecemeal with continuing and emerging upward trends in energy prices, costs of food production, consumption of increasingly scarce water resources in some regions and in migration/urbanisation. EU level policy adapts by allowing different but narrowly focused priorities and objectives for water resources in different regions but this causes disparity in economic growth prospects across Europe and exacerbation of the impacts from these different regional pressures. Ecosystem services related to water begin to deteriorate very significantly and public awareness of this is reinforced by a general realisation that CC effects become suddenly very real and very apparent after a period of ambiguous variability and even cooling. The EU policy- oriented government seizes the chance to raise public awareness even more on the cause and effect of these trends. Policies to de-carbonise Europe and to expand river basin planning to encompass multiple inter-linked objectives addressing local and regional issues are put into place. These succeed as increased participation in policy builds substantial public and local government support that is better integrated with EU programs over time. Europe finds itself at the forefront of this new socio-economic paradigm of public/private partnership and successfully leads a global shift in this direction while its own economic growth recovers.

Sustainability Eventually (SuE)

The SuE implies a crucial transition to regionally governed society, imposed in a top-down manner, fast and effective. The bottom-up regional decision making will follow more gradually. Behavioural changes are the last to occur. Trust based networks are created, linking NGOs and national government and public-private partnership's acceptance spreads. Much investments are placed in the development of water-saving technologies and by 2025, water demand stabilises; with measures to slow its growth down starting to show results. This transition is painful, slow, and not successful everywhere. Water poor countries form strong alliances and a water governance structure emerges, whereas water rich countries manifest a strong resistance against it and old water management structures persist.

3.1.2 LAND USE CHANGE INDICATIONS

SCENAR-2020ii study (Nowicki et al, 2009) is developed around two sets of drivers, exogenous and endogenous respectively, which are assumed to influence the evolution of agriculture up to 2020. Exogenous drivers (those which are not substantially altered by EU policy decisions within time period of study) are population growth, macro-economic growth, consumers' preference, agro-technology, environmental conditions, and world markets. Endogenous drivers (policy-related) that are expected to have a discernible effect within SCENAR-2020ii time horizon are EU agricultural policy, enlargement agreements, renewable energy policy, World Trade Organisation (WTO) and other trade agreements and environmental policies. SCENAR-2020ii develops, on the basis of these drivers, three potential policy frameworks in order to assess futures in rural EU: reference, conservative CAP, and liberalisation. The aim of the document was to examine the extent to which Community policies are adapted to challenges that European regions will face in the coming years and what the role of Community policies should be in responding to these challenges (Nowicki et al., 2009).

Table 1 Exogenous drivers in the SCENAR-2020ii scenarios (Nowicki et al., 2009:25)

Assumptions	Reference	Conservative CAP	Liberalisation
Demographics	major population trends as observed in the past	trends as in reference scenario	trends as in reference scenario
Macro-Economic growth	moderate growth as seen in trends increasing trend for labour market liberalisation	trends as in reference scenario	trends as in reference scenario
consumer preferences	more demand for value added and increasing absolute spending per capita consumption of organic and regional food as observed in the past	trends as in reference scenario	trends as in reference scenario
agri-technology	continuous trends in cost-saving technical progress biotechnology GMO seed varieties introduced progressively; use extended	trends as in reference scenario	trends as in reference scenario
world markets	outcome depends on other exogenous drivers. Trends in agri-markets, generally, as observed in OECD/FAPRI studies. change from these trends due to exogenous and policy-related drivers	trends as in reference scenario, endogenously adjusted for changes in policy-related second-level drivers	trends as in reference scenario, endogenously adjusted for changes in policy-related second-level drivers

As it appears from Table 1, there are no major differences between the three scenarios in terms of exogenous drivers, in contrast with the SCENES' storylines.

Of the three, the first is a 'Reference' scenario, in which plausible policy decisions, based on current CAP orientations, are carried forward in the time period of the study. Particularly, this means a 20% reduction of CAP budget in real terms (constant in nominal terms), the implementation of a Single Payment System (SPS) as of 2013, full decoupling, a 30% decrease in direct payments (DP) in nominal terms and a 105% increase of the European Agricultural Fund for Rural Development (EAFRD). Trade agreements are synthetically represented, e.g. the WTO Agreement is based on the Falconer paper.

The second is a 'Conservative CAP' scenario, which refers to a situation in which Pillar 1 payments remain higher than currently assumed, and where as a consequence – to achieve a financial balance in the assumed budget for the period – the Pillar 2 payments are commensurably less.

This means a 20% reduction of CAP budget in real terms (constant in nominal terms), the continuation of the results of the Health Check (HC) after 2013, a flat rate (regional model) implemented at national level, coupling as HC, and a reduced decrease (15%) of direct payments in nominal terms, a reduced (45%) increase of EAFRD relative to the Reference scenario. Trade policies are maintained as in the Reference scenario.

The third is a 'Liberalisation' scenario, in which all trade barriers are removed. The CAP budget is reduced by 75% in real terms (55% in nominal terms), all direct payments and market instruments are removed, and there is a 100% increase of EAFRD.

Biofuel targets of 10% in 2020, as set out in the EU Renewable Energy Directive are incorporated in all three scenarios. For sake of simplification, certain possibilities – such as the further enlargement of the EU – are not taken into account.

3.2 WP3: WATER RESOURCES AND AGRICULTURE IN SOUTHERN EUROPE – PROCESS OF CHANGE

The WP3 report collects information from previous studies on the use of scarce water resources in the 3 study areas. In addition, it gathers data about the present situation and trends on water management, processes of change and adaptation, factors of adoption of new technologies and main impact of new technologies on increasing water use efficiency. In this sense, information was gathered and analysed for the three case studies. For the different study areas, importance is mainly paid to key local water management issues.

3.3 WP4: COMPETITION OVER A SCARCE RESOURCE

This WP presents for the three case studies covered by the project (i) the Institutional Framework in the field of Water Resources and (ii) an analysis of selected stakeholders involved in water resources management.

Specific information about the stakeholders in each case study was collected through a questionnaire, with the purpose to achieve general information about water use conflicts and decision-making processes in each case study.

Such questionnaire is structured into three sections. These sections are arranged so that clear identification of the nature, opinions and roles of the stakeholders are provided, maintaining the privacy of every stakeholder, regardless of the role, nature and reach of their activities.

Thus, the first section was drawn to characterize the stakeholder in what concerns the nature of their water usage (private users, public users, etc), the type of activities they perform and the intervention level (Local to National). This section is structured so that every stakeholder may respond and feel that their situation is considered in the study and that no type of water need is forgotten. The second section was drawn to describe the type of water management and its processes, and to provide researchers with a good overview of the opinions that each stakeholder has regarding the management system in place. This section takes into account the type of activity and the level of communication and sustainable integration among respondent stakeholders. The third section considers the conflicts that may arise from such management system, attempting to frame each answer on the CC subject, approaching subjects as water availability, water quality, pricing systems and overlapping stakeholder´s competences.

The main aim of such questionnaire is to analyse the interactions among stakeholders (policy makers or not) at a case study area level. Identification of decision makers and stakeholders to be contacted should, firstly, rely on privileged informers to determine the individuals and institutions (farmers, industrial entrepreneurs, environmentalists, technicians and or managers of public agencies, water suppliers, etc.) to be questioned. The number of interviews depended on the level of diversity desired, as with any usability study, but it was considered that at least 8 stakeholders and/or decision makers needed to be contacted. The following concepts were taken into account:

- **Policy-maker**: They are essentially institutional decision-makers who could use the results of the project in their activity as water managers.
- **Stakeholder**: an actual or a potential user of water resources for different purposes (agriculture, industry, domestic consumption, recreational, communication, etc.). They have an interest in the decision taken and they are directly and indirectly affected by the decisions taken. They can be classified according to the following criteria (Bianchi, and Kossoudij, 2001):
    - Primary stakeholders: those ultimately affected by the decision, either positively (beneficiaries) or negatively.
    - Secondary stakeholders: intermediaries in the process of decision making and implementation
    - Key stakeholders: those who can significantly influence, or are important to the success/failure, of the decision taken.

These questionnaires were applied taking into account the national logistical possibilities: sometimes personal interviews with stakeholders were carried out, and others web-based questionnaires were sent via email.

3.4 WP5 & WP6 MAINSTREAMING CC INTO POLICY-MAKING

These two WPs were developed simultaneously and they mainly comprise of 2 parts: first the project identified instances of autonomous adaptations amongst local farmers and their planning priorities, which led to the initial development of alternative adaptation strategies, and then stakeholders were involved in their evaluation, through a multi-criteria method.

Everything was carried out with the support of online domains, increasingly recognised as important means for broadening participation. eParticipation is described as a tool that promotes the inclusion of the public in participative and deliberative decision-making processes, which contributes to the transformation of the relationship between politics and citizens (UN, 2007). Ideally, this approach should enable the public to become an actor in discussions and decision-making over public policies. Hence, in these WPs, an innovative approach to eParticipation was examined, that links online questionnaires to the data collection for - and development of - an online decision support system tool, mDSSweb, which builds on an existing downloadable tool developed by Prof. Giupponi and his team in previous research efforts.

3.4.1 FROM MDSS TO MDSSWEB

The main objective of this phase of ICARUS was to develop, consolidate, and test an online decision support tool developed ad hoc for the project, for supporting the mainstreaming of the CC discourse into policy-making. This tool is an updated version of an existing DSS software, mDSS (Giupponi, 2007), capable of managing the data required for providing informed and robust decisions by enabling integration of socio-economic and environmental modelling techniques and multiple-criteria decision methods. It is beyond the scope of this report to delve in details in all mDSS functionalities, which can also be found on www.netsymod.u/mdss - however on a general note, the existing mDSS tool comprises four main phases:

1. **Conceptual Phase** identifies the issues and explores the problem.
2. **Design Phase** includes the identification of the alternative options (strategies) and selection of the decisional criteria. The variables are organised in the form of a matrix - the Analysis Matrix (AM). AM is a table containing the indicator values expressing the performances of the alternative options for each decision criterion. After this, different criteria are ordered based on their importance, and their weights are calculated. One of the methods for providing criteria's values is the revised SIMOS procedure (Figueira and Roy, 2002), used in this case study. In this procedure, participants order criteria in a table, based on their relative importance, allowing for their hierarchic arrangement in a visual way.
3. **Choice Phase** uses Multi-Criteria Analysis (MCA) evaluation techniques to judge all options against their contributions to solve the problem, through the elaboration of the criterion values stored in the matrix. Three different decision rules are available in the mDSS software, Simple Additive Weighting (SAW), TOPSIS, and ELECTRE III.
4. **Group decision-making** (GDM) is a final phase that facilitates the identification of a compromise solution. The Borda rule is one of the offered GDM options (others are Condorcet and Extended Borda). Borda rule attaches a number of points to each strategy equal to the number of strategies ranked lower than it, so that a strategy receives n – 1 points for a first preference, n – 2 for a second, and so on, with zero points for being ranked last; where n is the number of strategies (Young, 1974).

The mDSSweb simplifies mDSS, by reducing the room for manoeuvre of the executor. Whilst in mDSS participants (experts) can choose among different methods offered in each phase (e.g. qualitative/quantitative definition of indicators, SAW or ELECTRE, Condorcet or Borda), the interface of the new software has fixed methods decided upon with end-users: likert scale for qualitative evaluation of indicators against different measures, SIMOS for indicators weighting, SAW for strategies' ranking, and Borda for group- decision making. The SAW method, utilised in the mDSSweb version, is a simple sum of the criterion values of every option, weighted by the vector of weights. The results are expressed by means of scores: the option with the highest score should be preferred.

3.4.2 First online questionnaire on "Agriculture, irrigation, and perceptions of current changes in the Veneto Region" (from Bojovic et al, 2012)

The first online questionnaire aimed at providing a set of most suitable adaptation strategies and criteria for their evaluation, identified by the local farmers (*Conceptual phase* of the DSS). The questionnaire examined farmers' perceptions over present and expected changes in the environment, economy, policy, and society. It also analysed whether cropping practices and water management have already undergone some changes in recent years and whether farmers saw a need for adaptation due to variability in climatic conditions and/or other changes.

The exploration of autonomous adaptation is the starting point for a bottom-up approach to climate policy as it allows the explanation of processes of change at the individual level (even if not directly labelled as adaptation to CC), as compared to planned adaptations, which are policy-driven. Together, planned and autonomous adaptations should cover: short term coping actions; longer-term transitions; purposeful and accidental adaptations; anticipatory and reactive activities; and activities motivated by non-climate drivers (Tompkins et al., 2010). The level of acceptance of planned adaptation strategies mainly depends on the people involved. Thus, comprehending the latter's motivation, knowledge, and perceptions is crucial for the effectiveness of the strategies (ibid).

For the Italian case study, farmers were recruited via the existing social network of Agro-Meteorological eBulletin users. The eBulletin is published by the Environmental Protection Agency of the Veneto Region (ARPAV). It is both hosted on their website and distributed through an e-mailing list. A specific Bulletin is issued for each of the 35 agricultural zones in the Region, up to twice a week in the irrigation period and less frequently during the rest of the year. The eBulletin was utilised as a means to distribute the online questionnaire to its 6,000 users, a much broader group of participants than we would have been able to engage with traditional face-to-face interviews.

The questionnaire was distributed between mid-July and mid-September 2011, as a link in each issue of the eBulletin. It was composed of 16, mostly close-ended questions, divided into two sections. The first section included socio–demographic information and farms' characterisation (size, income, crop production, and irrigation practice). The second section investigated irrigation techniques; perceived environmental, economic, social, institutional, individual changes, and any environmental pressure that has been influencing farmers' agricultural practice in the past 10 years. These were followed by questions on existing and needed adaptation measures in terms of crop and water management. Final questions explored the role of the eBulletin in improving agricultural practice, and what additional information should improve it. The last question offered farmers the option to leave their contact details.

The same exercise was implemented in the Spanish case study, where the questionnaire was sent through the eBullettin of a farmer's organization, "LA UNIÓ de Llauradors i Ramaders". This organization covers the geographical area of the Valencian Community and has approximately 20.000 farmers associated. The weekly e-bulletin is called "infoLAUNIÓdigital", is written in Valencian language and reaches approximately 500 members. A link to the survey was included in the num.53 of the eBulletin, sent in March of 2012, together with other weekly news. Before the link to the online survey, a motivational text included the title of the project, and asked for cooperation of the readers stating that it would only take 5 to 10 minutes.

3.4.3 Development and launch of mDSSweb

The second questionnaire consisted in the mDSSweb platform and it was composed of two sections. The first section presented a set of adaptation strategies that were drafted according to the outputs of the first online questionnaire, documentation review, and interviews with experts and policy makers of the regional administration. The adaptation strategies were proposed to the farmers for their evaluation in terms of seven criteria. Again, criteria were based on interests expressed in the first questionnaire and allocated in terms of the sustainability pillars (social, economic, environmental). For each criterion (question), strategies were evaluated via a likert scale, offering five options, from *very good* (5) to *very poor (1)*. The results of the questionnaire enabled the compilation of the AM. In the second section of this questionnaire, participants were involved in a criteria weight evaluation exercise, which was derived from the revised SIMOS procedure.

Spain and Portugal tested strategies and criteria with their local stakeholders, through meetings and short interviews.

For the second online questionnaire, we set up three parallel versions of mDSSweb, one for each case study – plus and English one for European policy-makers and experts. For the Italian version, we developed four sub-versions of the same frame, in order to be able to extrapolate different groups' perspectives. For instance, one version was sent to all the users of the online bulletin, another only to those who had left their email when answering the first questionnaire, one to the users of another online bulletin, more specialised on cereals management, and one to the irrigation boards.

Again, for the Italian case study, the questionnaire was distributed between beginning of July and end of September 2012, as a link in each issue of the eBulletin. Moreover, emails were sent to the subgroup from the first questionnaires in July and in September, and the link appeared once on another bulletin, in July 2012. Irrigation Boards were contacted in October. Results were presented to and discussed with Veneto Region policy-makers in December.

In Spain, in response to the low percentage of farmers reached by the online survey, a second phase of data collection was conducted with the collaboration of several farmer's organizations: the previously mentioned "LA UNIÓ de Llauradors i Ramaders", "COAGRI", a cooperative of agricultural producers located in Alginet village (Valencia province) and "La Comunitat de Regants de la Partida de l'Estell i Rojas" an Irrigator's Association located into the Albufera Natural Park. In this second phase, the ICARUS researchers contacted farmer's representatives and/or workers from the different previously mentioned organizations. In order to conduct the survey, either the questionnaire was sent to the farmers' associations, who conducted the survey in person, or a meeting with farmers was arranged with the help of farmers' organization, and coordinated by the team form the Universidad Politécnica de Valencia conducted the survey. By this means a total of 80 in-paper surveys were collected during the period June-September 2012. The surveys were then introduced in the web. This survey reached farmers from different counties or comarcas mostly located in the province of Valencia and Castellón, and some in Alicante province.

In Algarve, an initial search was made in spring 2012 concerning the entities that could be targeted in the questionnaire and identified their contact details. Later, in October 2012, about 120 organisations and individual farmers were contacted in order to communicate the importance of their participation into the project and also request their participation in the mDSSweb questionnaire (http://www.tiamasg.org/ICARUS/sawPT/). Taking into account the very low number of responses after a couple of weeks another email was sent requesting the participation of some entities already contacted (Table 2). Since the number of responses was not significant, these were also contacted by telephone. This means appeared more effective, however not entirely satisfactory. In most cases it was difficult to reach the responsible for the institutions, often due to the number of intermediaries, and even when he/she was reached, they not always were willing to collaborate. Hence the number of responses remained very low (5 answers).

Table 2 Contacted institutions in Portugal

Municipality	Entity	Typology
Lagos	Associação de Regantes e Beneficiários do Alvôr	collective irrigation cooperative
Loulé	AGRUPA - Agrupamento de Alfarroba e Amêndoa, CRL	agricultural cooperative
Loulé	Cooperativa de Produtos Agrícolas de Boliqueime, CRL	agricultural cooperative
Loulé	Sociedade Real Citrinos do Algarve, SA	agricultural cooperative
Silves	Associação de Regantes e Beneficiários de Silves, Lagoa e Portimão	collective irrigation cooperative
Silves	CITRIPOR - Cooperativa de Citrinos de Portugal, CRL	agricultural cooperative
Silves	FRUTALGARVE - Cooperativa Hortofruticultores S. Bartolomeu de Messines, CRL	agricultural cooperative
Silves	FRUTARADE - Cooperativa de Fruticultores de Silves, CRL	agricultural cooperative

4 Results

This chapter provides an overview of results achieved by the project. The project explored first scenarios of change, then drivers and processes of change, and finally it assessed an array of adaptation options in the agricultural sector. Overall, climate scenarios and economic scenarios show that by 2025 rainfall will decrease, temperature increase, and GDP growth will suffer a halt.

Farmers involved in the eParticipation process revealed that a great deal of autonomous adaptation is already occurring, which range from improved efficiency in farming technologies, increased irrigation intensity, introduction of irrigation, diffusion of groundwater exploitation, changing crops and/or crop management, and specialisation in non-food related agricultural activities, such as energy production from biomasses. However, the adoption of the technologies at farmers' level is dependent on a wide array of factors (farmer's age, full or part-time dedication, cropping pattern, generational relief, training, etc.), which shall be taken into consideration when designing ad hoc policies.

The main output of the project is an online decision support system (mDSSweb, in Figure 10), for the integrated management of supply and demand for water resources. It is a valuable tool for policy-makers, as it is highly flexible, easily adaptable to different contexts, it allows the involvement of hundreds of stakeholders, whose view are crucial for the success of policy design and implementation. Moreover, it permits the overcoming of temporal and spatial barriers, simplifies linguistic barriers, and eases knowledge and experience transfer.

4.1 SCENARIOS OF CHANGE

The following sections report CC, socio-economic, and land use change scenarios in the three case study of the project ICARUS, namely Central Algarve, Júcar river basin, and the Venice Lagoon Watershed. As mentioned above in the methodology section, this part of the project did not involve direct simulation of scenarios, but rather a comprehensive collection of data produced within other European projects.

4.1.1 CLIMATE CHANGE SCENARIOS

According the IPCC-A2 scenarios, in the three case studies, by 2025, precipitation patterns may vary as follows (Table 3):

Table 3 Variation in precipitation patterns, 2025

Precipitation	**Annual**	**Winter**	**Spring**	**Summer**	**Autumn**
Central Algarve	-15 to -5%	-15 to -5%	-5 to 5%	-5 to 5%	-5 to 5%
Júcar river basin	<-30%	<-30%	<-30%	<-30%	<-30%
Venice Lagoon Watershed	-15 to -5%	-15 to -5%	-30 to -15%	-5 to 5%	;-15 to-5%

Instead, the temperature patterns may vary as reported in Table 4:

Table 4 Variation in temperature patterns, 2025

Temperature	**Annual**	**Winter**	**Spring**	**Summer**	**Autumn**
Central Algarve	0-1°C	0-1°C	0-1°C	0-1°C	0-1°C
Júcar river basin	1-2°C	1-2°C	0-1°C	1-2°C	1-2°C
Venice Lagoon Watershed	1-2°C	1-2°C	1-2°C	1-2°C	1-2°C

The effect of changing climate on runoff is taken into account via the impacts of temperature and precipitation on the vertical water balance. Changes in precipitation will raise or lower the average volume of river runoff. Meanwhile, the expected increase in air temperature intensifies evapotranspiration nearly everywhere, and hence reduces runoff. These two effects interact differently at different locations and produce the net increase or decrease in average annual water availability (SCENES, 2010). Hence, according the IPCC-A2 scenarios, in the three case studies, by 2025 water availability may vary as follows (Table 5):

Table 5 Water availability trends, 2025

Water availability	**Annual**	**Winter**	**Spring**	**Summer**	**Autumn**
Central Algarve	-15 to -5%	-15 to -5%	-5 to 5%	-5 to 5%	-5 to 5%
Júcar river basin	<-30%	<-30%	<-30%	<-30%	<-30%
Venice Lagoon Watershed	-15 to -5%	-15 to -5%	-30 to -15%	-5 to 5%	-15 to-5%

4.1.2 SOCIO-ECONOMIC CHANGES

Population in 2025 does not seem to vary for the four development scenarios (Table 6).

Table 6 Population patterns, 2025

Population	**SuE**	**PoR**	**Foe**	**EcF**
Western Algarve	-50 to -25%	-50 to -25%	-50 to -25%	-50 to -25%
Júcar river basin	5 to 25%	5 to 25%	5 to 25%	5 to 25%
Venice Lagoon Watershed	5 to 25%	5 to 25%	5 to 25%	5 to 25%

Downscaling of GDP to NUTS2 level were carried out for the ClimWatAdapt project by the CESR group. Below there follows the potential difference in GDP between base year and 2025s of the counties our case studies are located in (Table 7). It appears that the share of local GDP to the total national GDP in Algarve remains stable, in Valencia experiences a slight increase for all four scenarios, whereas in Veneto it will decrease to half for all four scenarios.

Table 7 GDP variation, 2005 versus 2025

GDP	**2005**	**EcF**	**FoE**	**SuE**	**Por**
Central Algarve	0-0.2%	0-0.2%	0-0.2%	0-0.2%	0-0.2%
Júcar river basin	0.5-1%	0.6-1.1%	0.6-1%	0.6-1%	0.5-1.1%
Venice Lagoon Watershed	1-2.3%	0.6-1.1%	0.6-1%	0.6-1%	0.5-1.1%

Both SCENAR-2020ii studies demonstrate that the differences in CAP and trade policies have more effect on agricultural income and number of farms than on agricultural production. The future pattern of agricultural production in EU will generally be subject to international trade policy situation and domestic policies such as mandated biofuel incorporation into transportation fuel resources. Overall, this scenario study shows that there is increasingly a true dichotomy in the agricultural systems: on the one hand, there is a trend for specialisation (open field arable, horticulture and livestock-rearing dairy systems); on the other there is livestock based system with mixed cropping for fodder system, interlaced with fallow lands tending towards retirement from agricultural use.

SCENAR-2020ii study predicts that overall there is a strong probability of decline in the contribution of agricultural sector to the total income and employment within EU. This is accompanied by a decline in food processing, especially in Liberalisation scenario. However, impacts are unevenly distributed across EU.

Yet, all scenarios expect an increase in crop production, but since yield increases reflects technology improvement, the amount of land devoted to crop production can be expected to decrease (especially the liberalisation scenario, since specialisation and economy of scale would accompany shifts in market shares based on relative prices in open market). Some though are non-market determinants such as biofuel production, mandated by Renewable Energy Directive. In particular, biofuel arable crops will have a differentiated market under liberalisation: internal EU production requirement higher for crops used for ethanol than those for biodiesel.

4.1.3 LAND USE CHANGES

Land prices may decline, although to different extents in the three scenarios considered in SCENAR-2020ii. Decline of land prices: conservative -1%, mainly because of Natura2000 in the conservative scenario, -3.5% in the reference scenario, and up to -30% in the liberalisation scenario, primarily due to a reduction of border measure and direct payments.

Influence of liberalisation on EU-27 agricultural land use is negative, in spite of strong demand for arable crop land provided by the Renewable Energy Directive. Productivity gains diminish land required for crops. With reduction of beef consumption, even the needs for grassland for extensive pasture are progressively reduced and so is the utilised area. Removal of pillar 1 payments under liberalisation scenario would also translate into reduced agricultural land use, as an important revenue in farm income is removed. This will lead to an intensification of land use in core production areas (Spain?) to earn a decent living and to land abandonment in marginal production areas, as it becomes unprofitable to produce there (Italy,..). Nevertheless, compared to the reference scenario, in Portugal farm income may decrease by 2% (Conservative CAP) or 18% (Liberalisation); in Spain increase by 1% (Conservative CAP) or decrease by 18% (Liberalisation); in Italy +1% (Conservative CAP) or -13% (Liberalisation) (Nowicki *et al.* 2009).

The evolution of real prices for arable crops is generally negative up to 2020 in Reference scenario, with the exception of soybean, rapeseed and sunflower seed. Oilseeds have a high demand because of RED, with additional component of demand through by-product for livestock feed in the form of protein rich oilseed cake. Livestock activity in reference scenario generally experience a decline in total income, although pillar 1 and 2 support has a positive effect on revenues. Liberalisation scenario: production transformed into ethanol loses its market share to imported intermediary or final products. Income from all agricultural commodity production will drop by 30% (arable) to 60% (livestock) in Liberalisation scenario when compared to reference scenario (especially because of removal of Pillar 1support). However, according to the very authors, the impact of biofuel might be underestimated (Nowicki *et al,* 2009).

In short, the main impacts of SCENAR-2020ii's *Reference scenario* at EU level specific to land use patterns are expected to be the following:

a. Growth of biofuel production of 14% by 2020
b. Production of poultry increases by 15%, pork by 7% but beef declines by 11%

Instead in the liberalisation scenarios,

i. Growth of biofuel production of 3% by 2020 (same mandate as ref scenario but different origin of biofuel feedstock. Renewable energy directive will not be able to outweigh contrary consequence of reduced border effects in liberalisation scenario (better competitive advantage of crops or ethanol production outside EU) PLUS reduction of pillar 1 payments means less support for farm income generally
ii. Reduction in beef production more than 35% (limits growth of all meat products as demand for arable crops used for biofuel would cause the feed and land for livestock to become more expensive. And supplementary support for pillar 2 does not compensate for this.

For Veneto Region, a recent study argues that since land use has changed significantly in the past decade and is already highly exploited, it is not expected that it will keep changing drastically, although a significant conversion from arable to permanent crops may occur (35%) (Santini & Valentini, 2010).

Another study, which assesses policy alternative for coastal zones (uncontrollable development vs. sustainable planning) shows that unless protective planning is adopted, high developments in Spanish coastal areas between now and 2050 will lead to a further exploitation of natural resources, increase of pollution, and biodiversity losses (Lavalle et.al, 2011). Similarly, for the Central Algarve region, increasing urbanisation is likely to lead to a concentration of agricultural activities and production of waste which already stresses water recourses and is projected to worsen. Moreover, water extraction and the products used for agriculture, such as fertilizers, could influence negatively water quality and availability in the aquifers.

See Appendix 1 for more extensive summary of all data collected during WP2.

4.2 AGRICULTURAL WATER SAVING TECHNOLOGIES IN THE MEDITERRANEAN AREA

Agricultural water use depends on a wide array of climate, economic and institutional characteristics as well as on individual changes and collective decisions for crop and irrigation management.

On the whole, the present situation of irrigated agriculture is the result of extremely diversified situations, related not only to the difference in water availability, but also to the intrinsic variety of the agricultural systems, that vary from the most intensive (fruits, vegetables, flowers) to the most extensive systems (dry cereals, pastures). Consequently, also the role played by irrigation is quite different. Whilst in extensive systems it is mainly to increase the yields and reduce production variability, in many intensive systems irrigation is a fundamental premise for the possibility itself of practicing agriculture.

Irrigation faces a number of problems. One of the major concerns is the generally poor efficiency in the use of water resources. A relatively safe estimate is that 40 percent or more of the water diverted for irrigation is wasted at the farm level through either deep percolation or surface runoff. These losses may not be lost when one views water use in the regional context, since return flows become part of the usable resource elsewhere. However, they often represent foregone opportunities for water because they delay the arrival of water at downstream diversions and because they almost universally produce poorer quality water.

There are two main directions to deal with insufficient water availability, namely to reduce demand or to increase supply. Possible technical actions to reduce water consumption can be divided into three main measures (1) to increase supply, (2) to improve conveyance and distribution systems and (3) to improve irrigation techniques and technologies of water application to crops. In addition, there are other possible soft measures such as improving irrigation organization, management, and control; and promoting information support systems, such as online agro-meteorological bulletins.

4.2.1 INCREASING WATER SUPPLY

Water reserves' increase and/or use of alternative water resources

Water reuse and desalinisation are two water resources considered today as key available components of water resources planning to face the current water deficits, future scarcity and irregularity of water due to CC. The need of water reclamation or reuse in agriculture is occurring more frequently because of water scarcity, economic development and population growth.

Concerning the use of alternative water resources, several Mediterranean countries have included in their recent policies the development of desalinisation plants and reuse of treated wastewater. However, the use of desalination water for irrigation is currently limited due to the high price of water resulting from these treatments. As figure 2 shows, the volume of reused wastewater in Spain and Italy is the highest in comparison to other European countries. In Europe, Spain passed in 2007 a detailed decree (Royal Decree 1620/2007, Dec/7/2007) regulating treated water reuse that establishes possible applications as well as quality standards. No other European Union nation has regulated treated water reuse under the current European Water Framework Directive (WFD). The reuse of treated wastewater for agriculture has been mainly developed in the Vinalopó River Basin and on the Palancia River Basin (rivers also managed by the Júcar basin authority, *Confederación Hidrográfica del Júcar*).

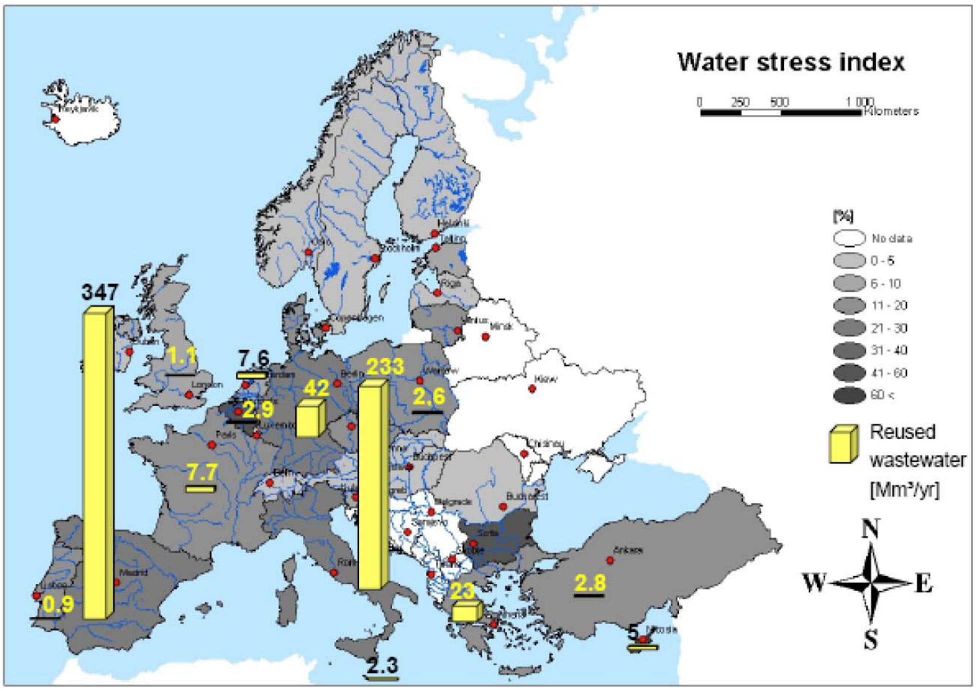

Figure 2 Volume of reused wastewater in Europe (UPV, 2012)

4.2.2 REDUCING WATER DEMAND

The possible technical actions to reduce water consumption can be divided into two main measures (1) to improve conveyance and distribution systems and (2) to improve irrigation techniques and technologies of water application to crops. Despite different approaches, the need to improve conveyance and distribution systems has become a significant issue. For instance, in Spain, most of the implemented measures have addressed the latter through the replacement of open canals with pressured or low-pressured pipelines. In this sense, the most widespread solution has been the shift to drip or sprinkler irrigation. However, water use efficiency is not so straightforward to improve. In the case of water use for irrigation, losses at farm level may not be lost when one views water use in the regional context, since return flows become part of the usable resource elsewhere. However, they often represent foregone opportunities for water because they delay the arrival of water at downstream diversions and because they almost universally produce poorer quality water.

In addition, there are other possible soft measures such as improving irrigation organization, management, and control; and promoting information support systems, such as online agro-meteorological bulletins.

Improvement of Irrigation Techniques and Technologies of Water Application to Crops

The alternative of improving technical efficiency in order to save water has been the option preferred by decision makers. What makes it most attractive is that improving technical efficiency is an uncompromising option that causes no clear “losers”.

However, the performance of the irrigation system depends not only on a proper development of the building and installation works but also on its subsequent maintenance. When networks are not properly designed and installed, results may be not as good as expected. Drip irrigation requires intensive maintenance and regular monitoring in order to achieve an adequate water management.

Besides, the introduction of advanced irrigation technologies can increase overall water use because of several reasons:

- Increases on crop production do not necessarily imply increases on water productivity. There are some difficulties on making simple predictions on water savings and yield responses.
- Irrigation efficiency depends on the irrigation method, irrigation management (frequency of irrigation, percentage of soil that is wet) and the crop itself.
- Some of this pressurized networks work effectively, however local and organizational factors have a strong importance which hinders the expected achievements.
- In some cases, advanced irrigation technologies can result in the expansion of the irrigated surface.

It is generally accepted that changing to drip irrigation modifies both the management and organization of irrigation and its costs. Economically speaking, the expected effects are: a) an increase in investment costs (although in some countries, i.e. Spain, part of the investment is subsidized by the government, farmers must finance a significant proportion of investment costs), b) a decrease in water supplied (initially, localized irrigation reduces the water losses associated to surface irrigation) and c) an increase in the cost per volumetric unit of water.

Similarly, the increase in the volumetric cost can be offset by a decrease in supply. Consequently, nobody knows the effect this could have on the cost of irrigation per unit of surface area, a priori, although it is assumed that improvements can be achieved in water productivity and the quality of the product.

The most noticeable characteristic is the significant variability on both per unit water use (m^3/ha) and water losses. Both are related with some expected factors (climate, type of soil, water flow, culture techniques, etc.) and also with some distinctive specific factors. The most important specific factors that influence water management are the source of water (surface or groundwater), farmers' characteristics (full or part-time farmers) and also the attributes of the irrigation association (internal organization, management rules, etc.).

Factors Conditioning the Use of Water Saving Techniques in the Júcar basin

In the Júcar River Basin (JRB) there is significant competition over water resources, where agricultural demand represents 80% of total demand. In addition, public policies aiming at conserving water have been implemented, mainly for the transformation from furrow to drip irrigation. In order to understand the process of adoption of drip irrigation technologies and its implications interviews were conducted to fifty-two farmers and members of the management boards of two irrigation communities, the Acequia Real del Júcar (ARJ) and the Canal Júcar-Turia (CJT).

The adoption of drip irrigation by the ICs was entirely promoted by public administrations in Spain. In the region of Valencia, it had the aim of assigning the released water resources to the Vinalopó River Basin (by means of the Júcar-Vinalopó water transfer). In this context, the expected water savings were the reason to finance up to 100% irrigation transformation in the Acequia Real del Júcar. Hence, in the case of ARJ, one important reason to shift to drip irrigation was to be virtually obliged by the relevant governments.

As stated by the interviewed members of the ICs (Acequia Real del Júcar and Canal Júcar Turia), the previous experience of drip irrigation in other ICs or farms constituted a positive example of the suitability of this type of technologies to the area. In addition, ICs mentioned as advantages of drip irrigation to be a more comfortable system, to obtain savings on fertilizer use and to obtain a higher production.

Once the decision to shift to drip irrigation was adopted and implemented by the IC, farmers could shift to drip irrigation at plot level, assuming the remaining cost of implementing this technology. One of the significant reasons to adopt drip irrigation at plot level was to be obliged by the IC. The main reason stated by farmers to adopt new irrigation technologies was to be obliged by the IC (51%). The remaining 49% sated other reasons. Out of those who mentioned other reasons, 24.2% mentioned being aware of other IC's or farmer's experiences, 14.9% mentioned obtaining a product of higher quality, 12.6% mentioned obtaining savings on money and labour, 11.5% mentioned drip irrigation to be a more comfortable system, 10.3% mentioned obtaining a higher production, 9.2% mentioned water savings, 8.1% mentioned fertilizer savings and 8% mentioned other reasons.

In addition, these technological changes have also significant implications on irrigation management practices. In Spain, where irrigation is managed collectively by user's groups, after drip irrigation implementation, the result is a more centralized irrigation management (including billing, fertilization, and operation and maintenance of the irrigation network). In these sense, some irrigation tasks previously managed at farmer's or Local Government Boards level (in Spanish, *Juntas Directivas Locales*) have started to be centrally managed by Irrigation Communities. This has an important impact on the institutional setting of irrigation management (monitoring and sanctioning, irrigation jury, technical staff needed, maintenance, etc.) which has to undergo a process of adaptation.

Results show that drip irrigation has led to a bureaucratisation of the irrigation staff and a decrease in the number of *regadores* (irrigation staff at field level). In this sense, the number of irrigation officers (in charge of maintenance and follow up of irrigation) has decreased from thirty-five to seven meanwhile the number of technicians has increased from zero to four (including both the ARJ and the CJT).

Changes in the irrigation network structure may also imply changes in the associated social capital, which is well established in some Mediterranean long lasting or traditional irrigation systems which have been in place hundreds of years. It should be noted that, before implementing drip or sprinkler irrigation, best practices for gravity-fed were also adopted around the Mediterranean to reduce water consumption. These rules implemented and controlled by the Irrigation Community, consisted mainly in having the land levelled properly, furrow irrigation, using a *turno*[1] system and conducting canals maintenance works regularly. At field level, farmers were required to follow best practices and irrigation rules, which are strengthened in situations of severe scarcity.

A final concern is related to the current socio-economic context. It should be noted that during the last decade farmers or IC have decided to invest in the transformation to drip irrigation. However,

[1] When using a *turno* system, irrigation is conducted following fixed order, generally an upstream to downstream, channel by channel and plot by plot until it reaches the end of the system. This order, based on the location of the plots, promotes water conservation by diminishing the total distance travelled by the water in comparison with an on-demand water distribution system.

the current economic situation has paralyzed the activity on most works. Currently, the State Government has made the investment for the installation of drip irrigation networks. However, due to the cut on government spending and the reduction of public sector debt, the Government of the autonomous region of the Valencian Community has not done its corresponding investment. This result in a significant delay on the execution of the works the regional government is responsible for.

Consideration of adoption of more efficient irrigation technologies

Although the improvement of irrigation efficiency should be targeted, the existing diversity has to be included in the decision making process and some aspects have to be considered:

- When shifting from gravity-fed to drip or sprinkler irrigation and surface water is the main water source, the introduction of new technologies results, generally, on a significant increase on energy consumption. In this sense, groundwater irrigation systems are expected to adapt more easily to pressurized irrigation.
- When implementing technical solutions, attention should be paid, similarly, to irrigation management, which have been shown to be a significant issue to improve efficiency.
- The adoption of the technologies at farm level is dependent on a wide array of factors (farmer's age, full or part-time dedication, cropping pattern, generational relief, training, etc.) which have to be evaluated before project implementation.
- The improvement of gravity irrigation systems is another important option to save water. Repairing or lining the existing canal networks can result on a significant decrease on water seepage, achieving an increase of efficiency up to 30-40% in some cases. Another less known alternative to improve application efficiency are *technologic gravity* irrigation systems, consisting mainly in using low-pressure gravity piped networks (efficiency can be similar to sprinkler irrigation). Even though it is mostly recommended for horticultural cropping, it has low initial investment costs (in comparison to sprinkler or drip irrigation) and does not require energy for their operation.
- In the current financial context, cuts on government spending and the reduction of public sector debt are expected. Hence, there is a risk for the execution of the building works governments may be responsible for; this can result on the incomplete or delayed implementation of irrigation works in detriment of agricultural users. This issue is currently significant in the Valencian region.
- In most cases, no proven statistical data on the amount of water used before and after implementation of irrigation technologies exist. Concrete knowledge, reliable and accurate statistics are essential for decision-making. In this sense, it is crucial to create information systems to support the decision and policy evaluation processes.

Finally yet importantly, any expansion of the irrigated areas must be limited if increasing availability of water is the aim of modernization policies.

Soft measures for reducing water demand

An essential feature of agriculture is the ability to adapt to natural variability to ensure long-term sustainability of food production. In addition to technical measures in irrigation, other strategies can help to improve water and irrigation management.

Change the cropping pattern by shifting to less water demanding crops

When farmers need to reduce the irrigated area, they usually adopt different cropping patterns- Often they switch to crops that are less demanding than those usually cropped, e.g. Replacing maize by sunflower, so to maximise water productivity. Changes in cropping patterns are favoured when farming systems are flexible enough to accommodate for different cropping techniques, i.e. not where permanent crops are cultivated.

In places where water has a price, the most important factor that has an influence on the adoption of water conserving measures is the price of water. In this sense, in Spain many of the farmers interviewed stated that in case of increase of the water price, they would rather abandon cropping than apply any other measures such as shifting to less water demanding crops or decrease water use with the already existing crops. This may be explained, as stated by most of the interviewees, by the fact that even though the price of water may important it is less significant than the current price of the harvest.

Horticultural crops demand and require significant amounts of water due to their perishable nature. Fruit trees and nut crops are not only comprised of large amounts of water, but the trees are perennial plants. Stress not only affects the current season's crop, but also future crops. Vegetables are also quite perishable but they represent annual crops and thus only one year of production is affected.

Planting alternative crops that require less water than traditional crops is an opportunity for producers to reduce irrigation water use, as well as to remain economically solvent in regions where water is scarce.

Improve Information Water Services to Farmers

Agricultural informatics is a new concept that has arisen due the rapid development in information and communication technologies (ICTs), and of the internet. Referred to as e-Agriculture, agricultural informatics is an emerging field, which combines the advances in agricultural informatics, agricultural development and entrepreneurship to provide better agricultural services, enhanced technology dissemination, and information delivery through the advances in ICT and the internet (Gakuro et al., 2009). The e-Agriculture concept, however, goes beyond technology, to the integration of knowledge and culture, aimed at improving communication and learning processes among relevant actors in agriculture at different levels i.e. locally, regionally and globally.

Especially when low resources are available, e-Agriculture allows a much broader reach of end users at a lower cost within a faster time, with significant benefits on agricultural production.

4.3 COMPETITION OVER SCARCE RESOURCES

Water resources are essential to life on Earth and play a key role in the development and functioning of society.

Sustainable development is being seen as the basis for a genuine balance between economic growth and environmental values. It means also to shift to a paradigm of natural resources management, instead of natural resources exploitation, to bring to a halt the present unsustainable patterns of production and consumption (UNDP, 2001). It is important, that at the same time man develops technology, which can enlarge the limits of the carrying capacity of ecosystems, to reduce, by means of effective policies, the patterns of consumption and to adapt practices of conservation of natural resources (Bartelmus, 1999).

Therefore, governance arises as a key issue to the implementation of sustainable development. It is an approach to understand and describe the systems, networks, practices and dynamics of governing. Good governance depends on the legitimacy of the political system and on the respect shown by the people for its institutions. It also depends on the capacity of such institutions to respond to problems, and to achieve social consensus through agreements and compromise (Machado et al, 2002).

In Europe, institutions responsible of water management are driven by a clear compulsory endpoint: the water status has to be good after Water Framework Directive implementation. The responsibility to carry out different measures should be shared among public authorities and stakeholders depending on competencies. This requires building capacity of involvement of all interested partners in catchments' planning and managing.

4.3.1 GENERAL DESCRIPTION OF INSTITUTIONAL FRAMEWORK

Italy

Until recently, the legislation on water in Italy has been highly fragmented in many laws and legislative acts addressing the issues of water exploitation, civil protection, environmental and water quality. Only over the last few years some efforts have been made to integrate different objectives, strategies and responsibilities in a coherent framework that takes into account a higher degree of complexity and decentralisation. Current legal background is essentially based on Act T.u. 152/06, which substituted all previous laws. However, it incorporated many of the previous major pieces of water legislation.

Portugal

In Portugal, there is a tradition of centralization of management and decision making, as regards to the water resources. As concerns the national level, the Ministry of Agriculture, Sea, Environment and Spatial Planning is the organization with the key role in defining strategic objectives and coordinating of many areas including the water management. The last years have shown an intense evolution of water legislative framework, clearly fostered by the European Water Framework Directive. In 2005, with the implementation of *Law of Water* (C.C.D.R.A, 2000), which transposed the Directive into national legal framework, was established the measures for sustainable water management.

Stakeholders' identification in the Hydrographical Region of the Algarve Streams

Stakeholders were chosen randomly among a list of entities and the characteristics of each were established after each stakeholder answered a pre-designed inquiry. Few Stakeholders responded to the inquiry.

The stakeholders that responded seem to have a great diversity of tasks concerning water management which, taking into account the amount of answers would imply that there are many stakeholders doing the same tasks. This subject of overlapping responsibilities was approach in the inquiry and approximately 30% of the respondents said that there is a lot of overlapping, especially in national and regional state run water management institutions. This shows that even though there is a great awareness about these subjects, there is also a lot of dispersion in the management. There are no answers of stakeholders that work in the Tourism sector, which is a poor indication of their willingness to discuss the water subject. Ultimately, one might say that the stakeholders who participated have a good awareness of community and group decision making, but there is a tendency for dispersion and, concordantly, bureaucratic constrictions.

Spain

Two instrumental laws are identified as the main precursors of water management: the Water Law and the Law of the National Hydrological Plan. The 2001 Water Law is a modern and comprehensive water code, covering all issues and aspects related to water policies, organization, procedures, finance, civil works, planning, and public participation. The Law of the National Hydrological Plan consolidates all Planning decrees for the different interregional basins, and lays down the basic principles of the Water Planning at the national level.

Stakeholders' identification in the Júcar Basin

In Spain, primary and secondary sectors have, together, make up for a considerable amount of all the water use. Recreational needs have also an important representation, which might be a sign of a change of paradigm of water value. This is probably due to the high impact of Tourism in the Jucar area and/or the existence of Golf Course type installations.

Concerning the autonomy in decision making unfortunately the answers provided are not satisfactory on account that almost 50% of the answers are "does not know/did not answer". Concerning the inputs used when making decisions, the Spanish system is where there is the best effort to have inputs from all social actors, keeping always in mind however that the Stakeholders have priority when making decisions. Taking into account the data gathered, one can say that the countries have taken different paths to the same final goal, of better water management, dealing along the way with the different realities of each countries in adjusted and pondered ways.

4.3.2 FINAL REMARKS: MANAGING WATER SCARCITY

The management of natural resources considered from the perspective of Sustainable Development requires an integrated approach of social, economic and environmental factors. However, all decision-making systems tend to separate these factors at the level of defining planning and management policies.

Water management presents specific difficulties due to its various uses and to the important functions that it performs in almost all aspects of human activity. It is not always possible to harmonise the various uses of this scarce resource. Thus the sharing of water resources requires management based on rules that render possible its harmonious appropriation, establishing priorities in use, regulating the interactions of the various social actors (individual and collective), or in other words regulating the conflicts not only among these various actors but also among the various users of the water.

The involvement of local people on the management of scarce resources, such as water available for agriculture activity, is a correct approach to try to solve some of the difficulties of decision-making processes. The participation of local stakeholders in decision-making processes has to do with giving them the power to mobilise their own capacities and therefore turning themselves in active actors rather than passive subjects.

Lundqvist (2000) approaches the changes in water management as different turns of a screw. At first, scarcity is recognised as a pure natural resource scarcity and the remedy is to “get more water”, which is accomplished by large-scale engineering efforts. Then, it is recognised that it may no longer be possible to develop additional large volumes of water. The effort at this stage is re-directed towards efficiency measures, predominantly to get “more use per drop”. This often induces significant changes in national policies, through the adoption of demand management strategies aiming at producing more with less water or to produce higher economic values from available water resources.

The modalities of water appropriation and management have been evolving for a long-time, but water remains a focal issue of the interactions nature/society being submitted to different types of policy options. However, these interactions have also been since long-time regulated through the law (PNUE/PAM/PLAN BLEU, 2004). In the last years, the increasing scarcity of water resources, and the induced tensions and conflicts, were responsible for the recognition of water as belonging to the public domain.

4.4 SUPPORT TO DECISION/POLICY MAKING (mDSSweb APPLICATION)

The tailoring of the tool was imbued with outputs from previous work packages. Information on global changes, water saving methods, and institutional settings were adopted to contextualise at best the evaluation part of the project.

4.4.1 FIRST EPARTICIPATION PHASE

The results of the first round of participation allowed the mapping of farmers’ perceptions on changes in economy, environment, and society, and their positions concerning needed and existing adaptation measures. These results clarified the state of affairs of water saving measures in agriculture, and obstacles for their implementation. This was an important input for consolidating adaptation strategies to be submitted for evaluation. Besides, analysing major farmers’ concerns and needs enabled proposing criteria for the strategies assessment.

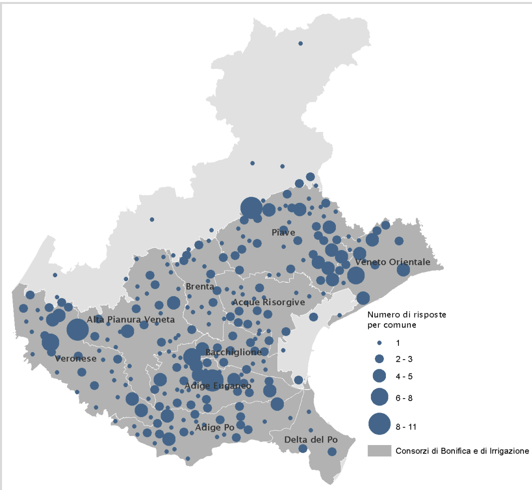

Figure 3 First questionnaire' spatial distribution of answers in the Veneto region

In Italy, with 590 individuals that completed the questionnaire, the sample presented almost 10% of the farmers contacted (AgroMeteo Bulletin users) and 0.5% of all the farmers (farms) in the region. Most of the responses were collected within a 10 day period starting from the questionnaire’s first publication in the eBulletin (Figure 4),hence this surveying process proved to be time efficient. Conducting traditional interviews, and with limited resources, it would have been highly unlikely to achieve a similar number of responses in the same time.

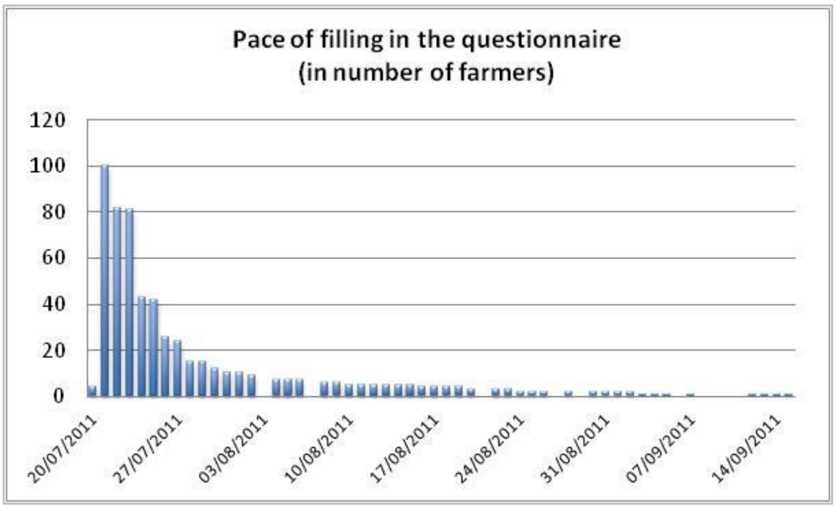

Figure 4 Reponses collection process (Italy)

Again for the Veneto Region case study, the results of the questionnaire showed that farmers are predominantly worried about economic change (Figure 5), followed by a concern over environmental changes. It appeared that farmers were worried about the future of agriculture, due to both farming continuity disruption and farms being abandoned by the youth. This is connected to the reported missing support for the local production, and a lack of support for small farms.

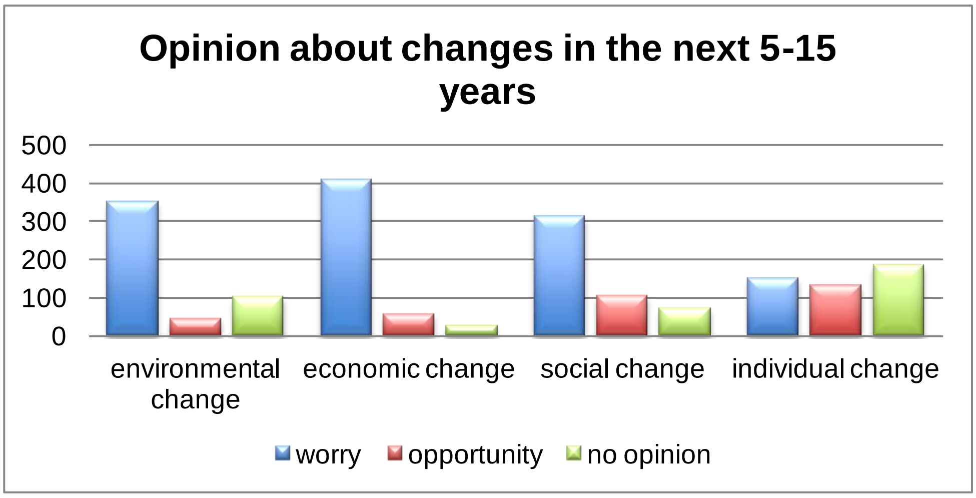

Figure 5 Veneto farmers' opinion about future changes

The results in Figure 6 show that the participants were aware that environmental changes have been influencing agriculture in the past 10 years, with 23% of farmers reporting tangible perception of shifting seasons, 22% changes in precipitation and 19% changes in temperature.

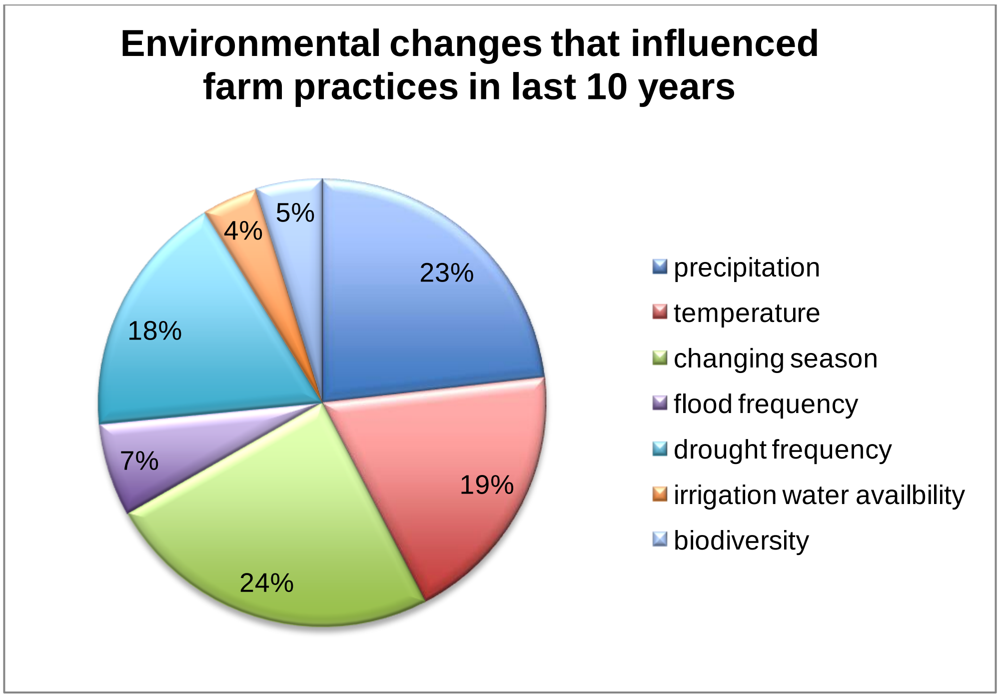

Figure 6 Veneto farmers' opinion about past environmental changes

Regarding crop and water management adaptations, the most frequent answer out of “I have done it”, “Others have done it”, “It is not necessary”, and “It will be necessary in the near future” was the latter. The most common agronomic interventions already in place were species or varieties diversification and introduction of integrated pest control (Figure 7). Commenting on this question, farmers suggested organic farming and biodynamic agriculture, together with the introduction of the biological pest control. This answer suggests a rather high presence of the organic farmers in the sample. Besides, the results show a high percentage of specialized farmers, mainly wine producers, among the participants.

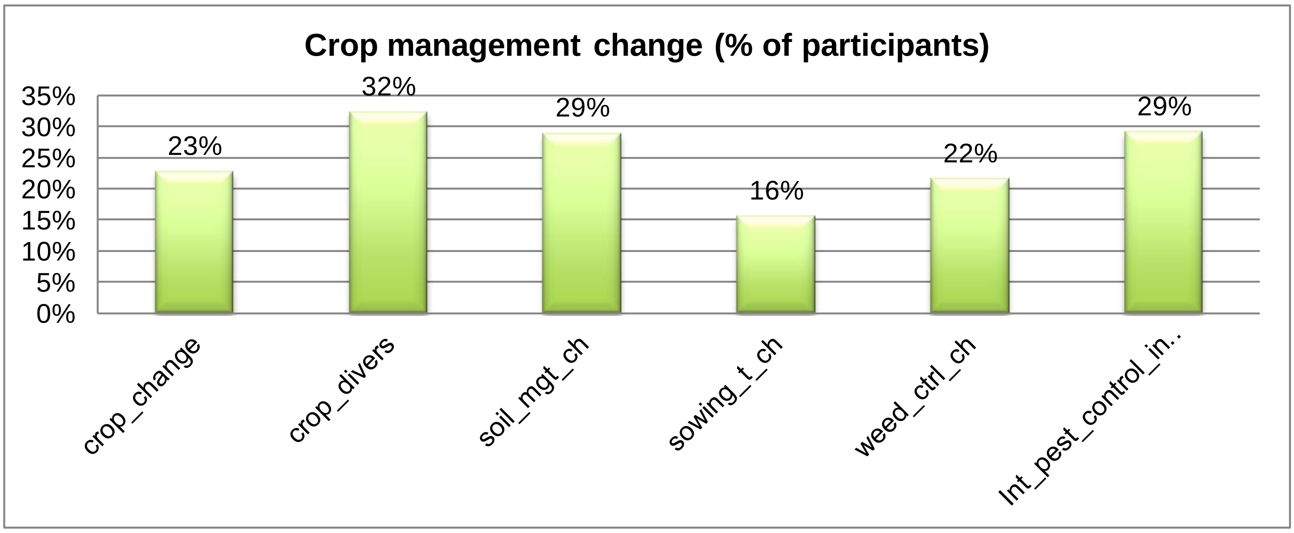

Figure 7 Veneto farmers' "autonomous adaptation" in crop management

The comments regarding water management change (Figure 8) were numerous, and the most frequent one was about the need for drip irrigation and water conservation measures, whilst some suggested the construction of either farm water tanks or dams in the hilly region. Some farmers complained about the quality of the service provided by the Irrigation Boards in charge of water supply. In October 2011, a brief report with the main results from the first questionnaire was published on the ARPAV's website.

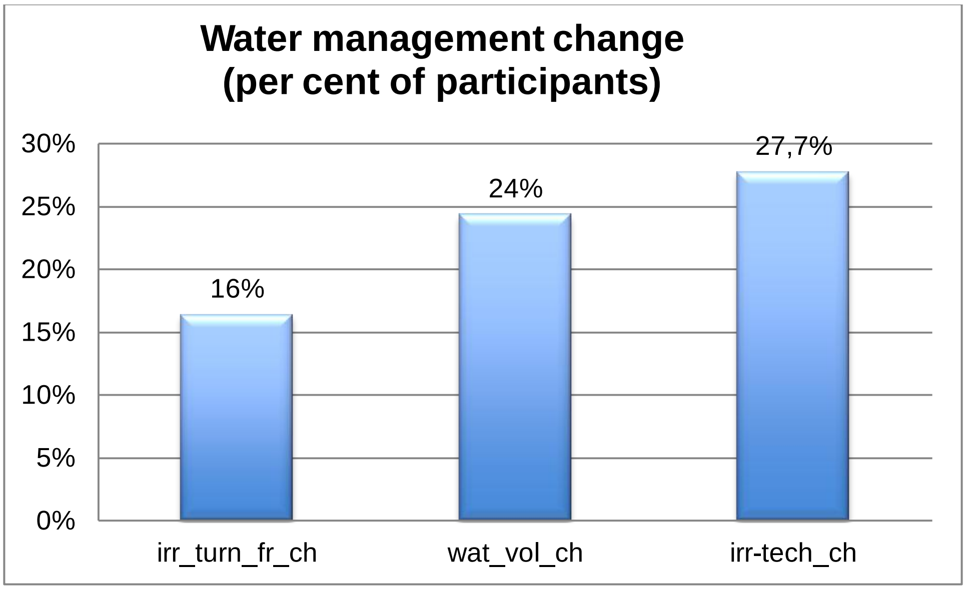

Figure 8 Veneto farmers' "autonomous adaptation" in water management

In Spain, out of 500 people contacted, only 7 farmers completed the survey. One factor explaining the low percentage of responses may be the average age of the Valencian Farmers. The agricultural population over 65 years represents the 44.91%, between 55 and 64 the 26.87% and between 45 and 54 the 17.08%, the remaining 11.14% is below 45 years old.

The results of the first questionnaire were further discussed with experts, and five general strategies (directions for investments): use of reservoirs for flood retention and water storage; desalination plants for augmenting water supply; prioritisation of low-water-requiring crops; investments in high efficiency irrigation technologies (sprinkle and drip irrigation); and investment in online climate services. Moreover, from farmers' answers, the following seven criteria were identified for ranking the strategies: contribution to farmers' income; return on investment; adaptability to potential future CC; contribution to resolution of conflicts regarding water allocation; rural development; feasibility; and environmental protection.

Figure 9 presents how the answers from the first questionnaire (green – direct answers), and (red –questionnaire analysis) determined adaptation strategies (blue) and evaluation criteria (light green)[2] that are used in the second questionnaire. Finally, the first online questionnaire enabled recruiting the farmers for the second phase, where they were more directly involved in the decision-making process. This process was repeated for all case studies, until we identified the measured mentioned in Table 8, specific to each of the areas.

[2] The last criterion (technical feasilbility) was not recognised by the farmers, but suggested by the experts from the region

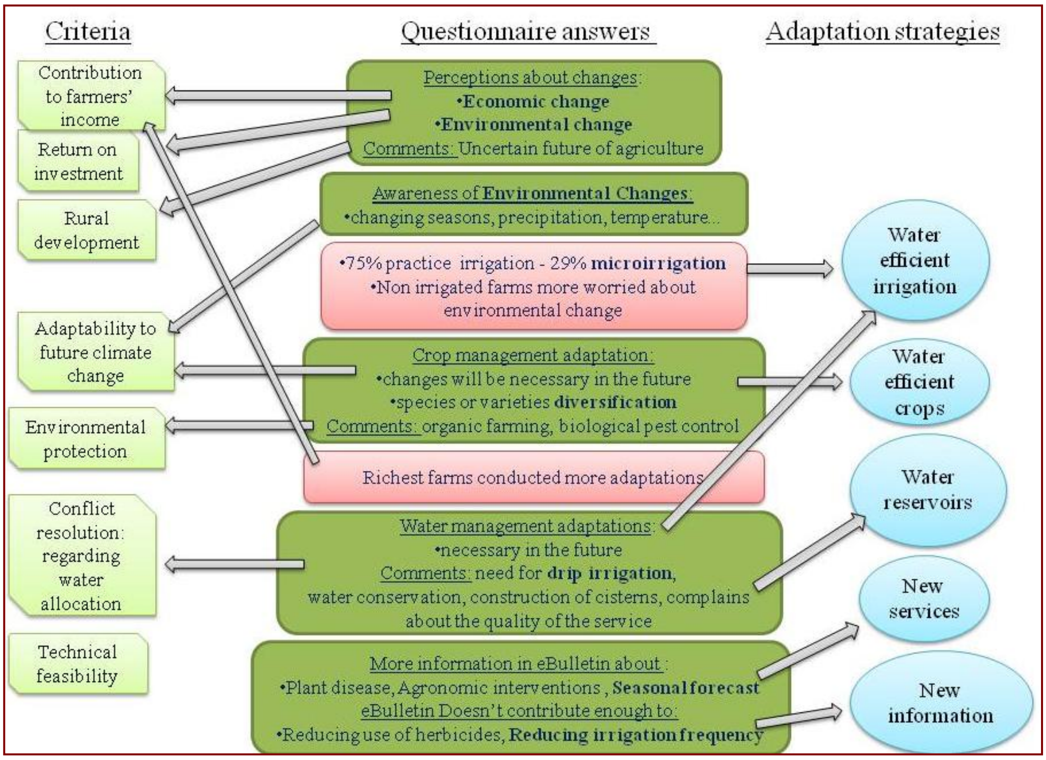

Figure 9 From farmers' answers to strategies and evaluation criteria (Bojovic et al, 2012)

Table 8 mDSS evaluation framework for the three case studies

		case studies		
		ITA	***ES***	***PT***
strategies	Increasing the capacity of water reservoirs (building new ones, restoring old ones);	x	x	x
	Production system's reorganisation towards less water demanding crops;	x	x	x
	Improvement of irrigation efficiency at the farm level (pluvioirrigation, microirrigation);	x	x	x
	Enhancement of existing information services for farmers (Agrometeo bulletins, seasonal forecasts, ...).	x	x	x
	New information system, i.e. seasonal forecast, to support crop choice on an annual basis	x		
	Wastewater treatment and reuse for agriculture;			x
criteria	Contribution to farmers' income	all	all	all
	Beneficio economico per la società in generale rispetto ai possibili costi di investimento			
	Technical effectiveness for improving adaptation to climate change			
	Containment of conflicts over water resources between agriculture and other sectors			
	Overall contribution to rural development			
	Contribution to environmental protection			
	Practical feasibility			

4.5 SECOND ePARTICIPATION PHASE

The main output of the second phase is the structure of the mDSSweb prototype and its tailoring to the three case studies. In other words, it had the primary aim to test the procedure to be implemented in the mDSSweb and the acceptability of the measures and criteria proposed specifically for the three areas. First we tested the prototype with farmers from the Veneto region.

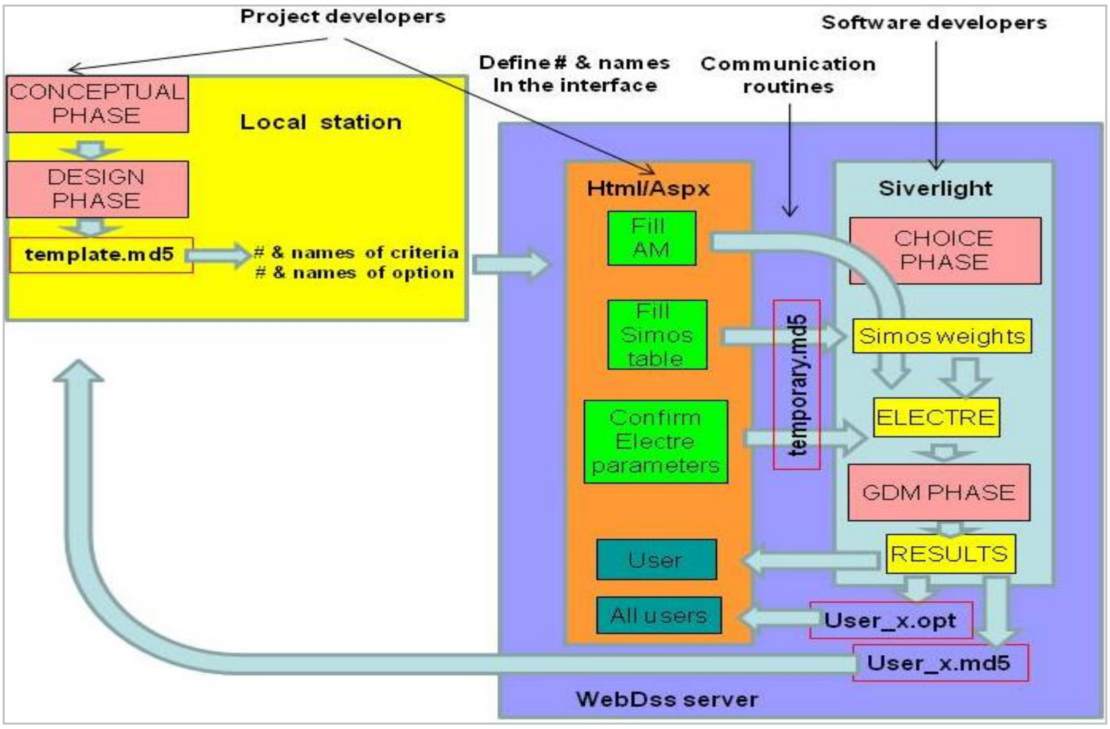

Figure 10 mDSSweb diagram

Participants to the second questionnaire generally praised the strategies chosen as particularly apt to the Veneto Region's needs and options for future investments. They also added comments on the approach – i.e. to simplify the first section of the questionnaire, which has now been turned into a matrix rather than the original series of questions, or to keep the SIMOS procedure, which in their opinion was intuitive enough. The comments were very useful for consolidating the mDSSweb. Overall, interviewees recognized the tool as powerful in identifying the agricultural sector's needs.

The steps from the Design phase to the GDM base are carried out online by mDSSweb, which displays both the results obtained by each farmer and the results of a group decision making, which includes all the participants' individual rankings (Figure 10). In the ICARUS mDSSweb platform, the Conceptual Phase of the original mDSS is predefined through the first questionnaire. An AM interface allows stakeholder to assign qualitative values (1-5) to the strategies according to the given set of criteria, which they then weight according to their preferences, through the SIMOS method (Design phase). After normalising the weights, the platform integrates the values of AM and criteria weighting into a ranking of strategies, through the SAW method (Choice phase). In the group decision-making phase, a winning strategy is calculated with the Borda rule, based on the choices of all the participants (GDM phase) (Figure 10).

This process supplies policy-makers with the necessary information to define how to direct investment priorities, with consideration of the preferences and expectations highlighted by this participatory process. This is expected to improve the effectiveness and acceptance of the final policy choice.

In Veneto, the consolidated version of the mDSSweb was sent to (i) those 370 participants who left their contact in the first online questionnaire and added as a link on the Agro-Meteo Bulletin utilised for the first questionnaire; (ii) to the whole AgroMeteo bulletin sample; (iii) to the users of another agronomic bulletin, and (iv) to all Irrigation Boards. In Spain, as mentioned above, participants were mainly contacted by phone. In Portugal, data failed to be collected, due to both shortage of funding and non-availability of farmers.

4.5.1 SOME RESULTS FROM SPAIN

Figure 11 below shows the ranking of farmers' preferences in the Júcar area. The implementation of more efficient irrigation techniques has been selected as the better option by the majority of the consulted farmers (45%), followed by the increase of the storage capacity (36%). The use of information services (11%) and the change of crops (7.5%) are considered secondary options. The change of crops is clearly the least preferred option (51%).

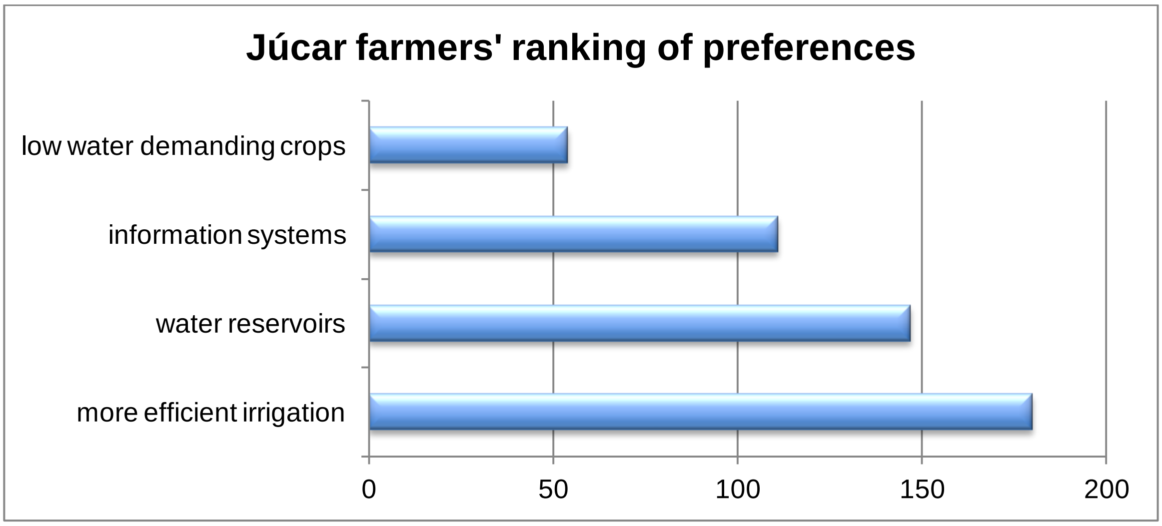

Figure 11 Spanish preferences in terms of investments for water saving in agriculture

No significant geographical trends have been detected in the analysis of the survey (Figure 12). The influence of the cropping patterns or the water distribution systems is also not relevant. The only exception is the refusal of increasing storage capacity in the Baix Maestrat area, where the high permeability of the substrate determinates the existence of rivers with a severe ephemeral regime and the impossibility to build dams.

Thus, there is a high territorial homogeneity of the obtained results and the focus on the survey analysis should be placed in factors related to the recent evolution of the National water policies. During the last three decades, the Spanish public administrations have stimulated actively the adoption of water saving technologies trough the subsidization of drip irrigation systems. The impact of this recent policy and the broad dissemination of a culture of water saving seems to be the main factor explaining the first position of the implementation of more efficient irrigation techniques in the survey.

This policy has been developed after several decades of massive dam construction. As a result of this, the water storage capacity of the country increased from 3 billion cubic meters (m^3) in 1940 to 40 billion (m^3) in 1980. In many basins, the use of the water storage capacity has never been maximized, due to the over-dimensioning of these infrastructures. However, the long period of application of this policy has impacted in the memory of the Spanish farmers, and the second position of the option “water storage” could be attributed to the inertia generated by this policy.

The scarce weight of the option "information services” could also be related to the scarce experience of Valencian farmers’ in the use of these services (and TICs in general). We should remember that this fact also hindered the development of the survey, which failed when we used internet questionnaires.

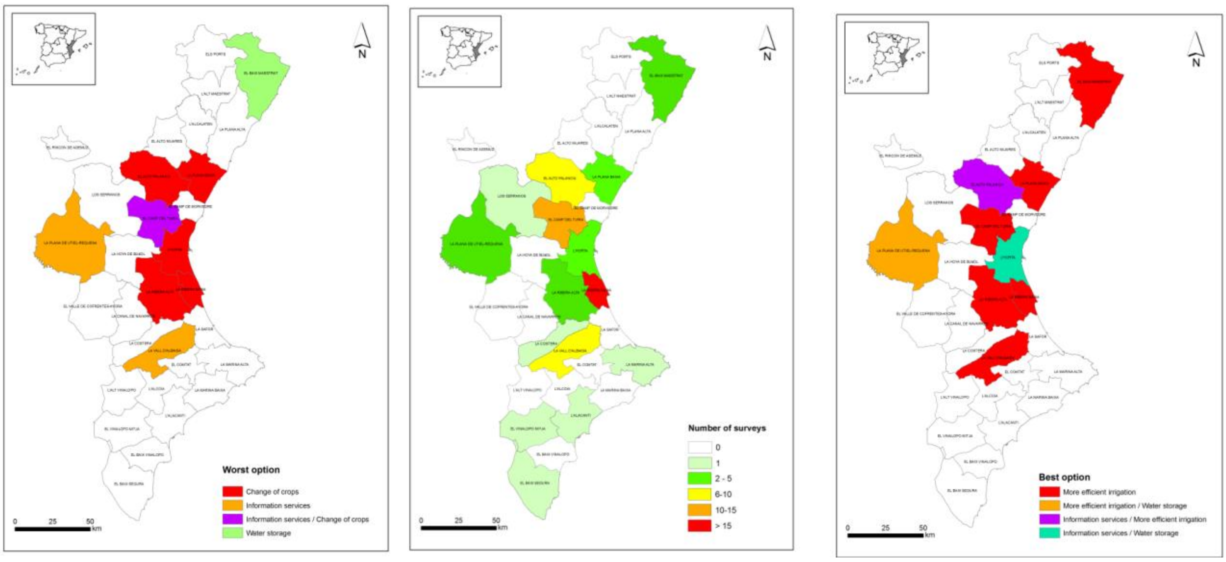

Figure 12 Spatial distribution of answers in the Júcar basin

Finally, market pressures and recent decreasing farmers’ incomes push clearly the “change crops” option to the last position. Another fact could be also underlined. This is the only option which depends only on the farmers’ decision (and then risks). The other three are collective or National politics decisions, to be developed in a wider political, financial or social framework and related also to collective risks.

4.5.2 SOME RESULTS FROM ITALY

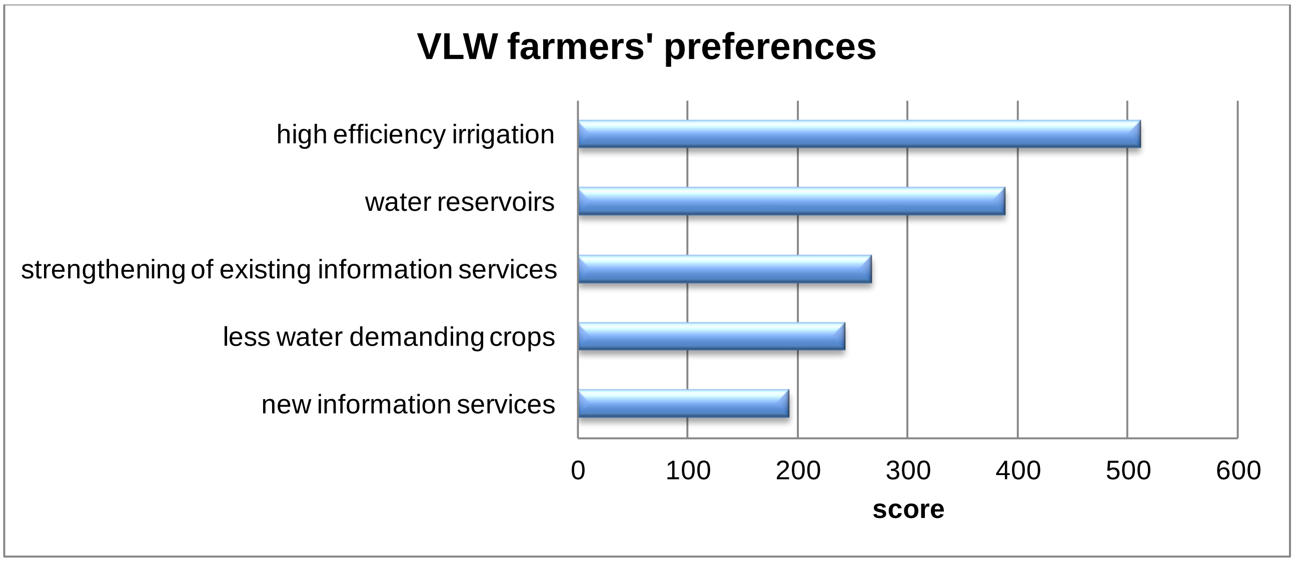

Figure 13 VLW farmers' preferences

Figure 13 above shows the final ranking of farmers' preferences. The overall results show a strong preference towards strategy C, which **suggests investments in highly efficient irrigation methods**, followed by strategy A, on the use of reservoirs and quarries as potential new sources for water storage (Figure 13). New climate services, whose potential the project wanted to explore, do not seem at the top of farmers' priority list. When farmers were asked about their reticence towards them, they often mentioned that the level of uncertainty is too high and they do not trust seasonal forecast. However, they do believe in the efficacy of existing information services. This ranking remains unaltered even when responses are analysed per sub-groups (farm surface, farm localisation, and irrigation technologies).

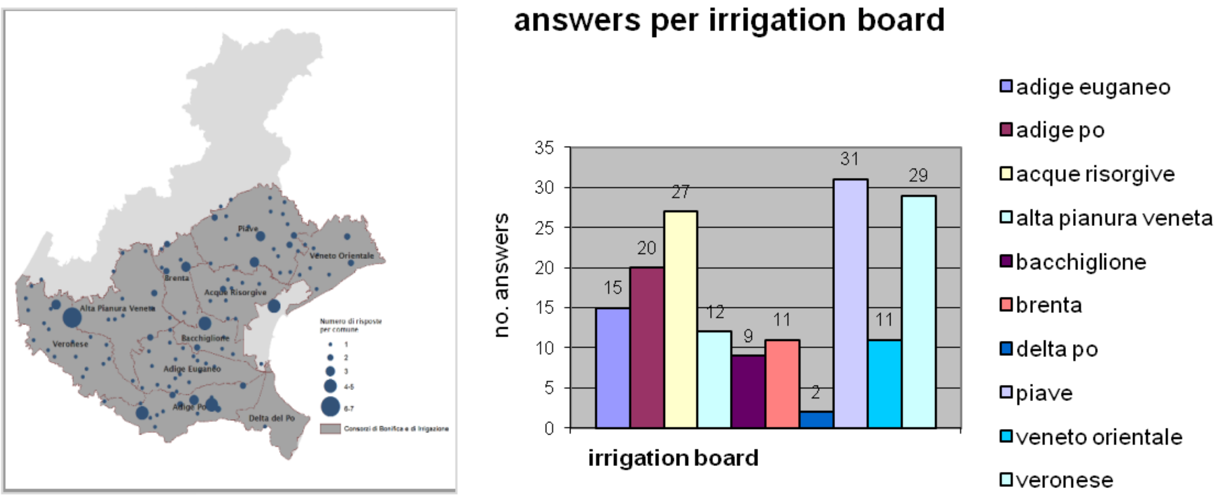

Figure 14 Distribution of answers in the Veneto region both across the area and amongst IBs

The total number of responses (168) is not high in absolute terms, but considering that it was a research project experiment and not an institutional activity, the number could be considered more than satisfying. Particularly positive is the transparency and efficacy of communication with stakeholders, proper documentation of the whole process, all achieved at a very contained financial cost. Moreover, the decision support platform is designed in a flexible way so to facilitate its tailoring in different decision-making contexts.

Another positive aspect is a good geographical distribution of the respondents (Figure 14, left). The highest participation was found in the Piave (31 responses), Veronese (29) and Acque Risorgive (27) Irrigation Boards (Figure 14, right). Although far from being a representative sample of the "Veneto farmer", we could however affirm that all typologies of farmers were represented in our group of participants, as Figure 15 shows below.

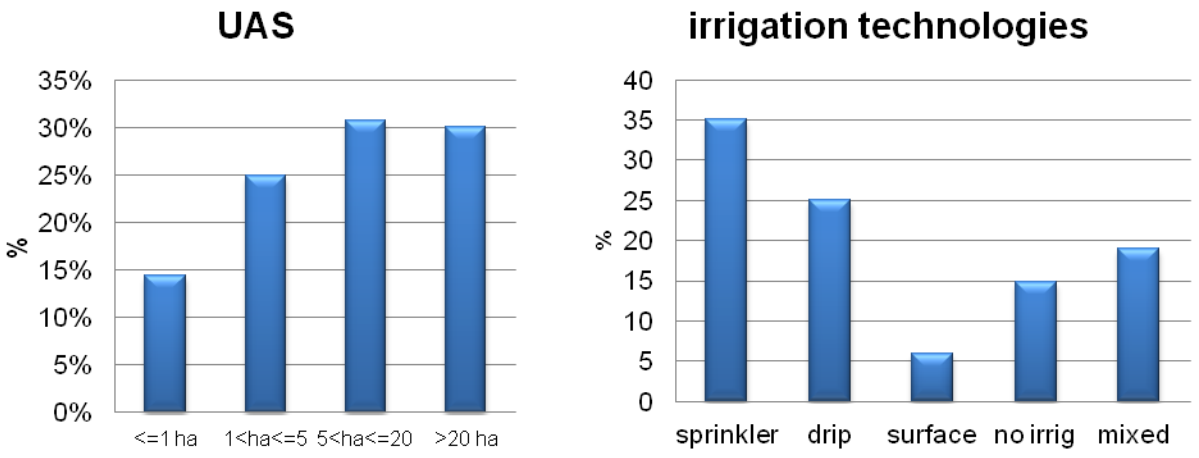

Figure 15 Distribution of answers per Utilised Agricultural Surface and irrigation technology

When analysing the answers of participants, their rank appeared consolidated even when dividing them into sub-groups, whether it was per farm surface, irrigation technology or localisation of the farm: C - investments in highly efficient irrigation methods –, followed by A – investment in augmenting water supply - remain stable at the top of farmers' preferences, whereas E – new information services, is the least preferred (Figure 16).

Keeping in mind the exploratory character of the exercise, it is also interesting to point out some other results. Strategy A (reservoirs and quarries) has been preferred by those farmers that have less than one hectare or more than 20 ha, while those with the average of 1-5 and 5-20 hectares are interested in the strategy B – less water demanding crops. The latter group also shows a higher interest than others in climate services (45% of the preferences). Regarding the irrigation type, those that do not practice irrigation or practice micro-irrigation prefer investments in climate services (54% of the D and E preferences), while farmers that practice surface irrigation prefer strategies A (26%), B (41%) and C (27%).

Statistical regression of the sample of farmers enabled an examination of some relations between variability of the preferences and characteristics of the farms. In particular, this analysis shows that the irrigation type and crops influence more significantly farmers' preferences than farm size and its location. For example, the use of drip irrigation increases the possibility of choosing the strategy A by 18%, while sprinkler irrigation increases by 40% the likelihood of choosing the strategy C.

More information can be extracted from the results collected in the platform, for instance the identification of different priorities and/or synergies; hence mDSSweb allows the smoothening of eventual sources of conflict. Figure 17 shows very different results obtained from members of an Irrigation Board and those collected from staff from the latter.

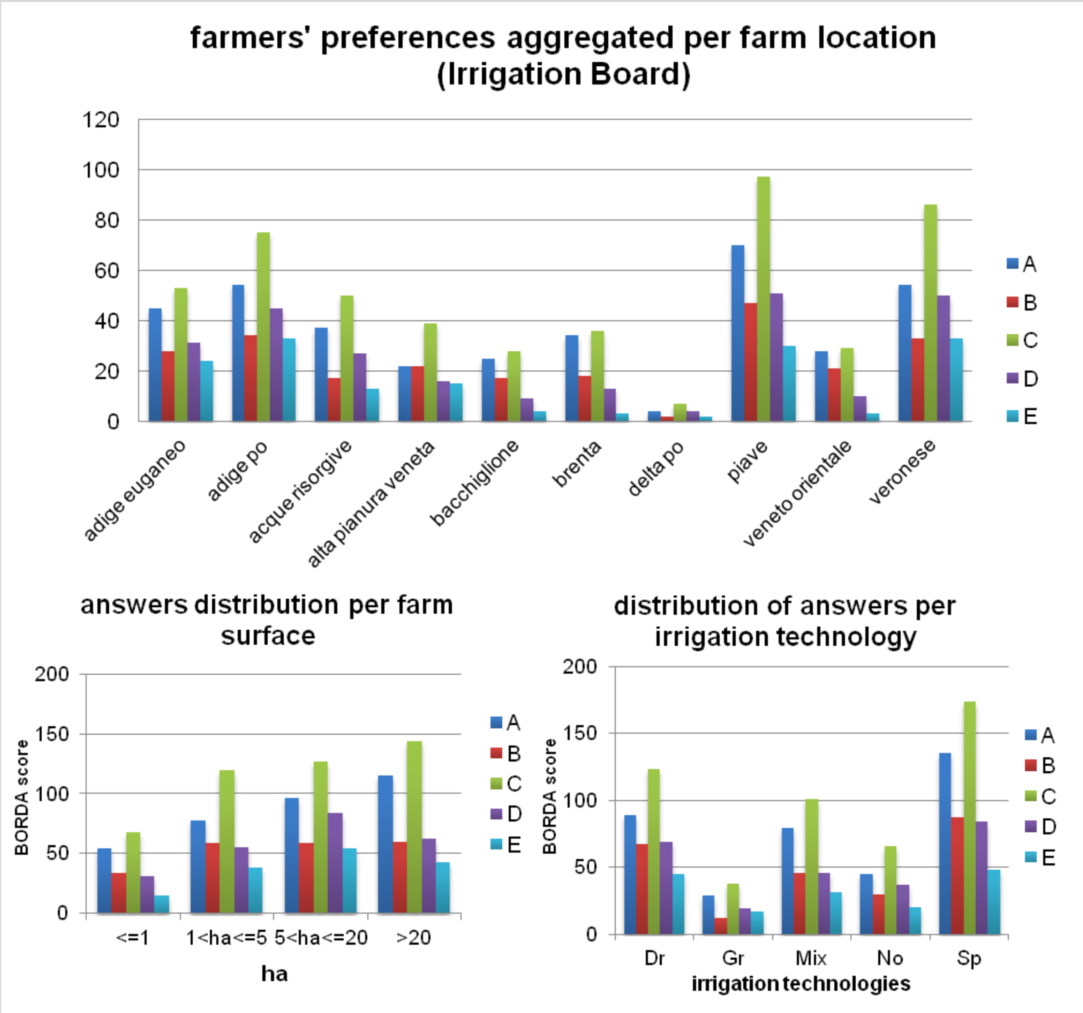

Figure 16 Distribution of answers per sub-groups

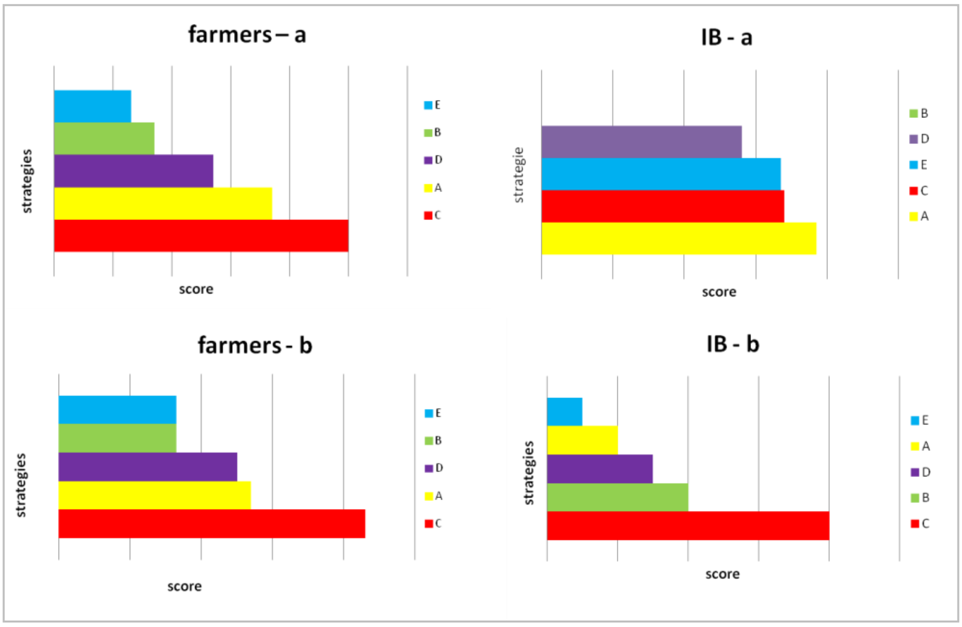

Figure 17 Farmers' preferences versus IBs'

4.5.3 CONSIDERATIONS ON LIMITATIONS OF THE MDSS APPLICATION IN PORTUGAL

As mentioned in the methodology, Portugal had both funding difficulties and lack of interest of stakeholders to participate in the project. Hence, with only 5 answers, which are even less than what could be collected in a traditional workshop, results are not significant.

4.5.4 CONCLUDING REMARKS ON THE EPARTICIPATION EXERCISE

The preliminary results of this research show that eParticipation techniques can effectively facilitate the involvement of large numbers of farmers in the processes aimed at supporting the design of CC adaptation strategies.

The two questionnaires' high absolute number of responses in Italy suggests readiness of the targeted agents to take part in the process, when contacted through an existing online social network. Although relative numbers (i.e. the rate of response) of the first questionnaire are similar to many other experiments and set at around 10%, the absolute numbers for both exercises are much higher than what could have been achieved through more traditional approaches, such as local meetings and face-to-face interviews, with limited resources in terms of time and money. The collection of numerous responses disclosed farmers' perspectives on current and expected environmental, economic or institutional changes, as well as present situation regarding autonomous adaptations.

However, the proposed approach, as is the case with any other participatory practice, is subject to self-selection of participants. This should not be overlooked when analysing and communicating the results to policy-makers. The obtained sample diverges from the Veneto Region statistics, for instance farms with vineyards are overrepresented. Nonetheless, not influencing the selection of participants helps to overcome other potential biases that could hinder objectivity in a conventional participatory practice. Moreover, it provides useful insight into the engagement and communication potential of online approaches and expected responses from different categories of farmers. Our sample suggests that professional farmers, such as wine producers, show higher interest and stronger motivation for the use of online services, which easily made them accessible for participation in the survey. Similarly, a high percentage of organic farmers in the sample suggests that this is a rather proactive group, ready to pioneer in innovative approaches.

A couple of comments left by farmers and policy-makers on the web platform:

> *This platform is a powerful tool for collecting opinions and exchanging experiences*

> *These results are very useful for maximising policy-making efforts, from design to implementation efficacy*

We may conclude that the combination of online questionnaires and mDSSweb, within an eParticipation framework, could provide robust decision support in mainstreaming climate change adaptation into local policies as it shows that autonomous adaptation must be considered, not least when studying the impact of CC on agriculture upstream of policy development. Hence, the platform promotes and facilitates a more inclusive engagement of local actors, and creating crosscutting networks that link the general public, in this case presented by farmers, with mediators (scientists), planners, and policy makers.

From a final meeting with policy-makers and representatives of the Irrigation Boards of the Veneto Region, we may also conclude that although the tool needs to be improved especially in terms of selection bias, there is a strong potential for its usability. All participants expressed favourable feedback in terms of opportunities it offers for improving communication between policy makers and beneficiaries and in its turn, enhance policy acceptability. Moreover, there was a general appreciation for its flexibility to be adapted to different purposes and for its “low cost low time” nature.

5 Discussion of Results

As coordinators of the project, we are confident that all objectives set in the beginning have been achieved. All work packages have been concluded successfully, despite several administration problems that one partner had to face.

Although not in the proposal, due to financial constraints encountered by a partner and overall limited budget of the project, we decided to develop a DSS tool online, with the purpose to reduce time and money efforts that usually full surveys and workshop organisation require. Although unfortunately the Portuguese partners received a very small percentage of what was agreed upon, we succeeded to develop an ad hoc tool for the assessment of water saving measures in their study area as well. In the end however, this led to more innovative results and much higher impacts (ie. much higher number of farmers involved)

The final conference provided the overall conclusion for the replicability of the ICARUS efforts at a broader Mediterranean scale – and by highlighting gaps and strengths of current research to "real world" gap, constituted the basis for the ICARUS policy recommendations (see Policy brief for further details)

6 Partners' Involvement

We can conclude that all partners contributed enthusiastically and proactively to the project's activities, which is even more remarkable given the near-to-total lack of funding of the Portuguese partners.

In Spain, in response to the low percentage of farmers reached by the online survey, a second phase of data collection was conducted in person, or meetings with farmers was arranged with the help of farmers' organization, and coordinated by the team from the Universidad Politécnica de Valencia conducted the survey. The surveys were then introduced in the web.

In Algarve, an initial search was made in spring 2012 concerning the entities that could be targeted in the questionnaire and identified their contact details. Later, in October 2012, about 120 organisations and individual farmers were contacted in order to communicate the importance of their participation into the project and also request their participation in the mDSSweb questionnaire. Taking into account the very low number of responses after a couple of weeks another email was sent requesting the participation of some entities already contacted. Since the number of responses was not significant, these were also contacted by telephone. This means appeared more effective, however not entirely satisfactory. In most cases it was difficult to reach the responsible for the institutions, often due to the number of intermediaries, and even when he/she was reached, they not always were willing to collaborate. Hence the number of responses remained very low (5 answers).

7 Recommendations for Future Work

The ICARUS project identified gaps in present policy-making for a sustainable management of water resources and developed its own proposals for an effective and sound policy-making.

7.1 LIMITATIONS IDENTIFIED BY ICARUS

The main policy limitations identified by the ICARUS project were discussed with several experts during the project's final conference, “Dialogue on water resources from research to livelihood impacts”. In particular:

1. The potential of models and economic policy instruments is well recognized in the research/academic environment, while it is often considered with scepticism by general public and policy makers. This is often due to **gaps in communication** between the two spheres, but also to specific problems, such as researchers not considering very important dimensions of local cultural background.
2. Limits in communication produce a cascade of negative effects, including the **lack of trust** between science and policy making. Building trust requires well established interaction mechanisms and time. Often only implementing institutions can create the necessary conditions for long term perspectives, as they have different time constraints than research institutes.
3. Quite often, the **knowledge produced by the academic/research environment is not fully exploited** by the potential beneficiaries, for different reasons, including very importantly their limited involvement in research design and implementation, which determines as a consequence that the needs of the latter are not taken adequately into consideration by the former.
4. In order to be effective, coordination should include methodologically sound and efficient approaches to manage **participatory process** for the involvement of broad groups of stakeholders, as a prerequisite for improving communication, building trust and increasing impacts.

7.2 RECOMMENDATIONS

On the basis of the limitations identified above, ICARUS recommends the following:

- ✓ The need emerges to bring to the surface the gap in the **communication** path from academia to institutions to final users and vice versa. The potential role and usefulness of research products and advanced tools, such as models, should be demonstrated in real world conditions, and their potential for improving business-as-usual should then emerge, an example being management and communication of uncertainty, which shall not be concealed but instead brought into decision-making practices.
- ✓ Platforms for **long lasting collaboration and trust building** should be established to provide the basis for effective knowledge transfer. The role of long term demonstration cases is paramount, for building trust about for example the potentials of innovative tools or policy mechanisms.

- ✓ New research funding mechanisms should carefully consider mechanisms to strengthen the links and increase potentials for **cooperation** between Universities and Research Centres – Institutions – Users. There should be no will to make social and economic interests to control scientific activities, but instead to have a voice in identify specific needs and conditions for operational implementation of expected outcomes, since the very early stages of research projects.
- ✓ **Participation** is not an option, is a must as the sense of ownership is fundamental for the successful of any development project and policy implementation. Not only pilot and demonstration projects and dissemination activities are very important, but also the potential of Web 2.0 should be fully exploited, as internet is a powerful tool to involve beneficiaries and setup efficient interactions with the academia.
- ✓ Therefore, the need emerges to identify approaches to improve the **coordination and integration** of assessment methods. It has been shown that the consideration of efficiency of water use in agriculture should be revised by including the consideration of a much longer chain of connected use for food production, energy, ecosystems, etc. For example, any approach to improve water efficiency should address also the fate of food products, including consideration of the water footprint of the huge amount of food wasted every day, as a part of the integrated cycle of an efficient resource use.
- ✓ An innovative concept of **efficiency** has been identified as a crosscutting dimension of water management, which requires new methodological efforts to be able to track it all along the biogeochemical cycle of water, across several sectors, such as agriculture, energy and buildings, but also through the ecosystems.

References

Allan T. (1999). Productive efficiency and allocative efficiency: Why better water management may not solve the problem, Agriculture Water Management 40(1), pp.71-75.

ANBI (1992). L'uso irriguo delle acque, Associazione Nazionale Bonifiche Irrigazioni. Miglioramenti Fondiari.

ARPAV (2007). Valutazione Ambientale Strategica per il Programma di Sviluppo Rurale 2007-2013 della Regione Veneto, Regione del Veneto, online document http://www.arpa.veneto.it/home2/htm/home.asp

Bartelmus, P. (1999). Economic Growth and Patterns of Sustainability. Wupertal Papers, Nº 98, Wupertal Institute for Climate, Wupertal: Environment and Energy, 16 p.

Bazzani G.M, Di Pasquale S., Gallerani V., Morganti S. e Viaggi D., (2003). Lo stato dell'irrigazione in Italia: problemi attuali e prospettive. Progetto Panda MIPAF.

Beaumont, P. (2000). The quest for water efficiency: Restructuring of water use in the Middle East,. Water, Air and Soil Pollution.

Bianchi, R. R. and Kossoudij, S.A. (2001). "Interest Groups and Organizations as Stakeholders", World Bank Paper 35.

Bojovic, D., Bonzanigo, L., Giupponi, C. (2012). Drivers of Change in Southern European Agriculture: Online Participatory Approaches for the Analysis of Planned and Autonomous Adaptation Strategies, iEMSS 2012 conference proceedings.

Brady, M. (2010). The impact of CAP reform on the environment: some regional results – Working paper. Paper presented to OECD Workshop on the Disaggregated Impacts of CAP Reform, 10-11 March 2010, Paris, France.

Braga, M. I. H. (1999). Integrating Freshwater Ecosystem Function and Services with Water Development Projects. Inter-American Development Bank, Washington.

Chiaudani A. (2008). Climatologia statica e dinamica del Veneto. Analisi del periodo 1956-2004, Tesi di dottorato, Università di Padova

CHJ (Confederación hidrográfica del Júcar), 2009. Overview of the Significant Water Management Issues. Júcar Basin District. Available online: http://www.phJúcar.com/docs/cons_publica/iniciales/Fichas0405_EdA.pdf, accessed 07/10/2011.

Clemmens A.J. and Molden D.J. (2007). Water uses and productivity of irrigation systems, Irrigation Science 25(3), pp.247-261.

Clemmens A.J., Allen R.G. and Burt C.M., (2008). Technical concepts related to conservation of irrigation and rainwater in agricultural systems, Water Resources Research 44.

Contò F., Trasatti E., Sabia C., (2001). Analisi tecnico-economica dei costi di investimento e di esercizio relativi alle innovazioni delle tecniche in irrigazione, Rivista di irrigazione e drenaggio, 48, 1, pp. 39-52.

Cots Ll. (2011). Desarrollo y calibración de un modelo de recursos hídricos aplicado a la cuenca del rio Corb dentro de la zona regable de los canales de Urgell (Leida), (PhD Thesis), Universitat de Lleida, Lleida.

Decree Law 112/2002, 17 of April. Diário da República no. 90 Serie I. Ministério do Ambiente e do Ordenamento do Território, Issue Lisboa.

ESYRCE (2010). Survey on Land Use and Crop Yields. Survey of Framework of Spanish Areas. Available online: http://www.marm.es/es/estadistica/temas/encuesta -sobre-superficies-y-rendimientos-de-cultivos-esyrce-/resultados-de-anos-anteriores, accessed 15/07/2011.

EURURALIS (2011). www.eururalis.eu Last accessed December 14,2011.

FAO (Food and Agriculture Organization of the United Nations) (2000). Technical Handbook on pressurized irrigation techniques, available at: ftp://ftp.fao.org/agl/aglw/docs/pressirrig.pdf.

Figueira, J., and B. Roy (2002). Determining the weights of criteria in the ELECTRE type methods with a revised Simos' procedure, Journal of Operational Research, 139, 317–326.

Gakuru, M., Winters, K. & F. Stepman, (2009). Inventory of Innovative Farmer Advisory Services using ICT. Prepared for: The Forum for Agricultural Research in Africa.

Gil Meseguer E. (2010). La región de Murcia, un laboratorio de experiencias de ahorro y eficiencia en el uso del agua: la modernización de sus regadíos, entre las políticas agraria y ambiental de la unión europea, Papeles de Geografía 51-52, pp. 131-145.

Giupponi, C., (2007). Decision Support Systems for Implementing the European Water Framework Directive: the MULINO approach, Environmental Modelling and Software, 22(2), 248-258.

IDEMA (xx). The Impact of Decoupling and Modulation in the Enlarged Union: a sectoral and farm level assessment, EU FP7 project, Contract No. SSPE-CT-2003-502171.

IDRH (2006). Contributo para a Implementação de uma Estratégia para o Regadio, Infra-estruturas Colectivas de Base Regional e Estruturação Fundiária, no âmbito do Plano Estratégico Nacional. Lisboa: Ministério da Agricultura, do Desenvolvimento Rural e das Pescas - Instituto de Desenvolvimento Rural e Hidráulica. Available in: http://sir.dgadr.pt/reg_doc_adm/upload/si_regadio_6.pdf

INE (1999). RGA – Recenseamento Geral da Agricultura (Agriculture General Census). Lisboa. Available at: http://ra09.ine.pt/xportal/xmain?xpid=RA2009&xpgid=ine_ra2009

INE (2009). Recenseamento agrícola - análise dos principais resultados : 2009. Lisboa. Available at: http://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_publicacoes&PUBLICACOESpub_boui=119564579&PUBLICACOESmodo=2

INE (2011). Uso da Água na Agricultura (Water Use in Agriculture). Lisboa. Available in: http://ra09.ine.pt/xportal/xmain?xpid=RA2009&xpgid=ine_ra2009_publicacao_det&contexto=pu&PUBLICACOESpub_boui=119577896&PUBLICACOESmodo=2&selTab=tab1&pra2009=70305248

IRSA-CNR (1999). Un futuro per l'acqua in Italia. Roma.

ISTAT (2012). 5° Censimento generale dell'Agricoltura – Presentazione dei dati definitivi: Veneto.

ISTAT, (2002). I principali risultati del 5° Censimento Generale dell'Agricoltura 2000. Roma.

ISTAT (2011). Censimento Generale dell'Agricoltura, Preliminary results.

Jensen M.E. (2007). Beyond irrigation efficiency, Irrigation Science 25(3), pp.233-245.

Lamoglie C. (2001). L'acqua, un bene prezioso. L'informatore agrario, n. 15.

Landa L. (2010). Modernización del regadío en Castilla y León. Aspersión o gravedad tecnificada. ¿Cual es mejor alternativa?, in: Proceedings of the XXVIII National Conference of the National Association of Irrigation and Drainage, June 2010. León, Spain.

Lavalle, C., Rocha Gomes, C., Baranzelli, C. and Batista e Silva, F. (2011). Coastal Zones Policy alternatives impacts on European Coastal Zones 2000 – 2050. JRC Technical Notes, Publications Office of the European Union, Luxemburg.

Leão, P.; Morais, A. (2011). MECAR: Metodologia para a Estimativa de Água de Rega em Portugal. in INE, Uso da Água na Agricultura, pp. 17-42.

Lecina S.,Isidoro D., Playán E.and Aragüés R. (2010). Irrigation modernization and water conservation in Spain: The case of Riegos del Alto Aragón, Agricultural Water Management 97 (10), pp. 1663-1675.

Leone G., (1997). Stato delle Irrigazione in Italia, Comunicazione diretta.

Lundqvist, J. (ed.) (2000). New dimensions in water security. Water, society and ecosystem services in the 21st century. Rome: FAO. 82p.

Machado, C. R.; Lourenço, N.; Jorge, M. R.; & L. Rodrigues (2002). Sustainability: Importance of social networks in the decision-making processes. In Proceedings of the Conference Policies and Tools for Sustainable Water Management in the EU.

Maia, R. (xx). The EU Water Framework Directive implementation in the Iberian context. Faculty of Engineering of the University of Porto.

MAOT (Ministério do Ambiente e do Ordenamento do Território) (2002). PNA - Plano Nacional da Água (National Water Plan). Lisboa. Available at: http://www.inag.pt/inag2004/port/a_intervencao/planeamento/pna/pna.html or http://www.inag.pt/index.php?option=com_content&view=article&id=9&Itemid=69

MAPA (Ministerio de Agricultura Pesca y Alimentación) (2001). Plan Nacional de Regadíos, Horizonte 2008. Subsecretaría, Dirección General de Desarrollo Rural.

Massarutto A., (ed.) (2001). Water pricing, the Common Agricultural Policy and irrigation water use. Draft report. Udine, Italy.

Ministério da Agricultura, do Desenvolvimento Rural e das Pescas. (n.d.). Aproveitamento Hidroagrícola de Silves, Lagoa e Portimão. Retrieved June 25, 2012, from http://sir.dgadr.pt/conteudos/regadios/outra_inf_relevante/reg_Exploracao2011/Algarve/Silves_Lagoa_Portimao.pdf

Ministério da Agricultura, do Desenvolvimento Rural e das Pescas. (xx). Aproveitamento Hidroagrícola do Alvor. Retrieved June 25, 2012, from http://sir.dgadr.pt/conteudos/regadios/outra_inf_relevante/reg_Exploracao2011/Algarve/Alvor.pdf

Ministério da Agricultura, do Desenvolvimento Rural e das Pescas. (n.d.). Aproveitamento Hidroagrícola do Barlavento Algarvio. Retrieved June 25, 2012, from http://sir.dgadr.pt/conteudos/regadios/fichas/reg_Potenciais/DRAP_Alg/Barlavento.pdf

Miranda Ivars M. (2011). Análisis de la problemática actual en el funcionamiento de hidrantes en redes colectivas de riego a presión. Diseño de un hidrante tipo y elaboración de las prescripciones técnicas que deben cumplir los elementos que lo component, (MSc thesis), Universidad Politécnica de Valencia, Valencia.

NIS (National Institute of Statistics), 2009. Environmental Statistics. Environmental Statistics about water use. Available online: http://www.ine.es/, accessed 15/10/2011.

Nowicki, P., V. Goba, A. Knierim, H. van Meijl, M. Banse, B. Delbaere, J. Helming, P. Hunke, K. Jansson, T. Jansson, L. Jones-Walters, V. Mikos, C. Sattler, N. Schlaefke, I. Terluin and D. Verhoog (2009) SCENAR-2020ii – Update of Analysis of Prospects in the SCENAR-2020 Study – Contract No. 30–CE-0200286/00-21. European Commission, Directorate-General Agriculture and Rural Development, Brussels.

Nunes Correia, F. (2005). “Turning Political Commitment into Action”, Statement of Mr. Franscisco Nunes Correia, Minister of Environment, Spatial Planning and Regional Development at the Thirteenth Session of the Commission on Sustainable Development. United Nations. Thirteenth Session of the Commission on Sustainable Development.United Nations. New York.

Pereira, L. S. (2007). Uso Eficiente da Água e Métodos De Rega. Instituto Superior de Agronomia. Lisboa. Available in: http://ceer.isa.utl.pt/cyted/2007/ecuador2007/

Pereira, L. S. and T. J. Trout. (1999). Irrigation methods. In: H.N. van Lier, L.S. Pereira, and F.R. Steiner (eds.) CIGR Handbook of Agricultural Engineering, vol. I: Land and Water Engineering, ASAE, St. Joseph, MI, pp. 297-379.

Perry C. (2007). Efficient Irrigation; Inefficient Communication; Flawed Recommendations, Irrigation and Drainage 56 (4), pp. 367–378.

Perry C. (2008). Pricing Savings, Valuing Losses and Measuring Costs: Do We Really Know How to Talk about Improved Water Management?, in: Albiac J., Dinar A. (eds.), The Management of Water Quality and Irrigation Technologies, Earthscan, London, pp. 179- 196.

Perry C., Steduto P., Allen R.G.and Burt C.M. (2009). Increasing productivity in irrigated agriculture: Agronomic constraints and hydrological realities, Agricultural Water Management 96 (11), pp. 1517–1524.

Phang C.W., and A. Kankanhalli (2008). A Framework of ICT Exploitation for E-Participation Initiatives. Communications of the ACM, 51 (12).

Pindado P. (2005). The Spanish Programme of Improvement and Modernization of Traditional irrigation systems, in: Proceedings of the OECD workshop on agriculture and water: sustainability, markets and policies, November 2005; Adelaide, Australia.

Playán E. and Mateos L. (2006). Modernization and optimization of irrigation systems to increase water productivity, Agricultural Water Management 80 (1-3), pp. 100–116.

PNUE/PAM/PLAN BLEU (2004). L’eau des Méditerranéens : situation et perspectives. No. 158 de la Série des rapports techniques du PAM, Athènes: PNUE/PAM. 366p.

Portela, M., Almeida, A. d., & Machado, M. (April 2009). Development in river basin management in Portugal – past and future perspectives. Striver Technical Brief(10).

Qureshi M.E., Grafton R.Q., Kirby M. and Munir A.H. (2011). Understanding irrigation water use efficiency at different scales for better policy reform: a case study of the Murray–Darling Basin, Australia, Water Policy 13(1), pp.1-17.

Ramos, C. (2005). "Os Recursos Hídricos", in C.A. Medeiros (dir.), Geografia de Portugal, vol.I – O Ambiente Físico, Círculo de Leitores, Lisboa, p.388-415.

RBMP – RH8 (2011). Plano de Bacia Hidrográfica das Ribeiras do Algarve, (Basin Plan of Algarve Streamns). Available at http://planogestaorh8.arhalgarve.pt/

Regione Veneto, (2004). Agricoltura. In: Il Veneto si racconta -Primo Rapporto Statistico 2004 Segreteria Regionale agli Affari Generali a cura dell'Unità di Progetto Statistica.

Risse, T. (2002). Transnational actors and world politics. In Handbook of International Relations. ed. W. Carlsnaes, T. pp. 255–74. Sage, London.

Rodrigues, R. (1996). Institutional Framework for Water Resources Management in Portugal. Proceedings of the Euro-Mediterranean Conference on Local Water Management. Retrieved 2012, from Marseille: International Office for Water: http://www.oieau.fr/euromed/anglais/ate_4/rodrigu.htm

Rogers M, and M. Bruen (1998). Choosing realistic values of indifference, preference and veto thresholds for use with environmental criteria within ELECTRE. European Journal of Operational Research 107, 542–551.

Rogers, P.; Hall, A. W. (2003). Effective Water Governance. TAC Background Papers No. 7, GWP, Stockholm.

Sabo, O., J. Rose, and L. S. Flakm (2008). The shape of eParticipation: Characterizing an emerging research area. Government Information Quarterly 25, 400–428.

Sanches Ibor, C. (2011) CC scenarios in Júcar district. Internal document.

Santini, M. and Valentini, R. (2010) Predicting hot-spots of land use changes in Italy by ensemble forecasting. Regional Environmental Change. Springer-Verlag 2010.

SCENES (2011). http://www.1stcellmedia.de/customer/uni/cms/

Seckler D. (1996). The new era of water resources management: From "dry" to "wet" water savings, Research Report 1, International Irrigation Management Institute (IIMI), Colombo, Sri Lanka, doi: 10.3910/2009.003.

Shanian, A., A.S. Milani, C. Carson, and R.C. Abeyaratne (2008). A new application of ELECTRE III and revised Simos' procedure for group material selection under weighting uncertainty, Knowledge-Based Systems 21, 709–720.

Solanes, M.; Gonzalez-Villarreal, F. (1999). The Dublin Principles for Water as Reflected in a Comparative Assessment of Institutional and Legal Arrangements for Integrated Water Resources Management. TAC Background Papers No. 3, GWP, Stockholm.

Sotte, F. (2011). Agriregionieuropa. Associazione Alessandro Bartola, Studi e ricerche di economia e politica agraria. Year 7, No. 25.

Spanish Official Gazette (2002). RD 329/2002, of 5th of April, to approve the National Irrigation Plan. Vol.101 of 27/4/2002, pp. 15558-15566.

Spanish Official Gazette (2008). Order ARM/2656/2008, of 10th of September, to approve the Instruction for Hydrological Planning, IHP. Vol. 229 of 22/9/2008, pp. 38472- 38582.

Sumpsi Viñas J.M., Garrido Colmenero A., Blanco Fonseca M., Iglesias Martínez M.and Varela Ortega C. (1998). Economía y Política de Gestión del Agua en la Agricultura, Ministerio de Agricultura, Pesca y Alimentación (Coedición), Ed. Mundi-Prensa, Madrid.

Teodosiu, C.; Barjoveanu, G.; Teleman, D. (2003). Sustainable Water Resources Management. River Basin Management and the EC Water Framework Directive. Environmental Engineering and Management Journal, 2 (4), pp. 377-394

Tompkins, E.L., W.N. Adger, E. Boyd, S. Nicholson-Cole, K. Weatherhead, and N.A. Arnell (2010). Observed adaptation to CC: UK evidence of transition to a well-adapting society, Global Environmental Change 20, 627–635.

UN (2007). e-Participation and e-Government: Understanding the Present and Creating the Future, Department of Economic and Social Affairs Division for Public Administration and Development Management, United Nations, New York.

UN/WWAP (2003). UN World Water Development Report: Water for People, Water for Life. World Water Assessment Programme. UNESCO and Berghahn Books, Paris, New York and Oxford.

UNDP (2001) Human Development Report 2001. Millennium Development Goals: A compact among nations to end human poverty. United Nations Development Program, New York, 367 p.

Veneto Agricoltura (2011). Rapporto 2010 sulla congiuntura del settore agroalimentare Veneto.

Veneto Region (Regione del Veneto) (2011). Rapporto Statistico 2011- il Veneto si racconta, il Veneto si confronta, Regione del veneto, Direzione sistema statistico regionale, 2011

Verhoog (2009). SCENAR-2020ii – Update of Analysis of Prospects in the SCENAR-2020 Study – Contract No. 30–CE-0200286/00-21. European Commission, Directorate-General Agriculture and Rural Development, Brussels.

Ward F. A. and Pulido-Velazquez, M., (2008). Water Conservation in irrigation can increase water use, Proceedings of the National Academy of Sciences 105 (47), pp. 18215–18220, doi: 10.1073/pnas.0805554105.

Whelan M.J.,Hope E.G. and Fox K. (2002). Stochastic Modelling of Phosphorus Transfers from Agricultural Land to Aquatic Ecosystems, Water Science and Technology 45 (9), pp. 167–176.

Zucaro, R., and A. Povellato (2009). Rapporto sullo stato dell'Irrigazione in Veneto, programma interregionale, Istituto Nazionale di Economia Agraria (INEA).

Appendix 1: **data collected and available for the project and future uses**

			Format	Source	VLW	JRB	PORT	Additional info
Variables	Climate	Daily precipitation in mm, scenario A1B, for 2015 and 2030 for Júcar and Alentejo basins, 2015-2030 for 4grid cells in VLW – this allows us to calculate the delta P in the time-period we are assessing	Júcar and Alentejo basin's average values, 4 grid cells in VLW, where 4 repres. weather station are situated (Stazione 80CF (Castelfranco), Stazione 80ZB (Zero Branco), Stazione 80LE (Legnaro), Stazione 80AA (Agna)).)	CMCC	SWAT and agro-hydrologic model in SIMILE: input	x		
		Change in mean precipitation (seasonal, annual) in mm, scenarios IPCM4/SRES A2 for the period 2010-2039; 5 by 5 arc minutes grid (approx. 6 x 9 km in central Europe); (.shp, .pdf)	Europe and Northern Mediterranean	SCENES		x	x	
		Daily Temperature at 2m in °C for the period 2015-30, scenario A1B, (.txt), for 2015 and 2030, 14x14km grid cells	Average values for Júcar basin area and individual data for 4 grid cells in VLW	CMCC	x			
		Absolute change in mean seasonal and annual temperature to climate normal (1961-1990) in °C, period 2010-2039, scenarios IPCM4/SRES A2; 5 by 5 arc minutes grid (.shp,.pdf)	Europe and Northern Mediterranean	SCENES	x	x	x	to compare with A1B scenario, given the short time scale difference should not be major

		Evapotraspiration in mm/d, year 2015 and 2030, scenario A1B, 14x14km grid cells – this allows us to calculate the delta ET in the time-period we are assessing	Average values for Júcar basin area and individual data for 4 grid cells in VLW	CMCC	SWAT and agro-hydrologic model in SIMILE: input	x (to calculate deltas)	x (to calculate deltas)	
		(solar) radiation in mm/d, year 2015 and 2030, scenario A1B, 14x14km grid cells	Average for Júcar basin area and individual data for 4 grid cells in VLW	CMCC	SWAT and agro-hydrologic model in SIMILE: input	x (to calculate deltas)	x (to calculate deltas)	
		Wind speed, m/s, daily values for year 2015-30	VLW	CMCC	SWAT and agro-hydrologic model in SIMILE: input			
		Humidity, daily values for year 2015-30	VLW	CMCC	SWAT and agro-hydrologic model in SIMILE: input			
		Percentage change in mean annual and seasonal potential water availability aggregated on basin-scale estimated for the 2025s assuming the IPCM4/A2 climate scenario. → driving forces: P and T's mean monthly values	Europe and Northern Mediterranean	SCENES	x	x	x	Only the effect of climate input is taken into account as the impact of water uses was not considered in these

								calculations. In the IPCM4-A2 scenario, water availability is decreasing almost everywhere in Europe.
		Irrigation water stress index, seasonal, 2050s, IPCM4/A2 climate scenario	Europe and Northern Mediterranean	SCENES	x	x	x	
		Seasonal and yearly water stress (Mm3 water availability and water withdrawals, and water availability to water withdrawals ration (water exploitation index)) aggregated on basin-scale, period 2010-39, scenarios IPCM4/SRES A2; MIMR/SRES A2 (.shp)	Europe and Northern Mediterranean	SCENES	x	x	x	

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