



THE FUTURE OF SUSTAINABLE IRRIGATION MANAGEMENT IN EUROPE

Policy recommendations for decision makers and water management organizations

Agriculture accounts for 33% of fresh water use in Europe, while in southern regions it reaches up to 80%. As water quantity and scarcity concerns arise globally, sustainable irrigation water management is deemed necessary to maintain present agricultural production levels and is addressed in **EU Common Agricultural Policy (CAP)** and its latest reform 2014-2020 and in the **Water Framework Directive (WFD)**. Under the WFD, member states are required to achieve full cost recovery of water services via water pricing, taking into account also environmental and resource water cost. Additionally, one of the main CAP instruments promoting sustainable water management is the **Cross-Compliance Scheme (CCS)**, penalizing with subsidy cuts farmers that do not meet environmental requirements regarding water use. The combined application of WFD with CCS of the EU CAP introduces the price of water as an instrument for reducing its consumption and pollution, making the rationalization of water consumption a prerequisite for economic viable agriculture.

Sustainable irrigation management mainly involves irrigation scheduling and irrigation technology. EU policy frameworks place great expectations upon technologies to improve water efficiency and the European Commission emphasizes **'technological innovation in the field of water, given that water efficiency will be an increasingly important factor for competitiveness'** [CEC, 2008]. Advanced irrigation technologies and scheduling are expected to be assessed and adopted in combination with other environmental friendly technologies at the farm level. But despite the plethora of various solutions that have been developed over the last years, the adoption of such technologies by farmers is still low. This happens because other factors such as social behavior of rural communities, economic constraints, legal and institutional framework and agricultural practices also influence dramatically the adoption.

The purpose of this Policy Brief is to summarize the outcomes of **ENORASIS EU-FP7** project *Task 7.3 'Policy-related activities and recommendations'* regarding basic conclusions and policy recommendations, on the appropriate means and actions that if utilized could maximize the adoption of sustainable irrigation management in European agriculture.

ENORASIS at a glance

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2.085.965, 00 €

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KEY RECOMMENDATIONS

✓ **Sustainable and fair irrigation water pricing**

Raise irrigation water prices gradually, control and charge private groundwater extraction, eliminate illegal abstraction, install water meters, establish volumetric pricing. Design water policies adjusted to area local characteristics with progressive, seasonal, overconsumption water tariffs differentiation.

✓ **Improve water conveyance and field application efficiency**

Reform old water transport networks, eliminate water losses from leakages, install localized irrigation systems in farms.

✓ **Economic incentives on sustainable irrigation management adoption by end users**

Support installation of advanced irrigation scheduling systems, improvement of in-farm irrigation technologies, reform of water conveyance systems, installation of water metering equipment, promotion, awareness raising and training campaigns, capacity building of extension services for information, advice and technical support.

✓ **Understand farmers' attitudes and perceptions regarding irrigation and organize awareness raising and promotion campaigns**

Convince farmers that the adoption of advanced irrigation management systems bears lower overall cost over time than not doing water savings.

✓ **Communication and knowledge exchange through irrigation advisory services**

Establish the provision of irrigation advisory services from public or group organizations: communication and listening process with all stakeholders and scientific and technical support to farmers for the use of advanced irrigation systems.

✓ **Focus on end-users needs**

Support the conversion of knowledge into simple, easily accessible and affordable irrigation scheduling systems.

✓ **Promotion of advanced irrigation scheduling systems: Prioritize in specific target groups and target areas**

Target groups to prioritize promotion: water providers of public or private interest, farmers' collective entities.

Target demographic group: young farmers, familiar with new technologies and with environmental/agricultural training.

Target areas: Areas with high irrigation water prices, areas that suffer from water scarcity, areas with high-value crops with crop quality dependent on irrigation.

✓ **Add value to green water management**

Support localized storage of rainfall water for a more sustainable agricultural water management

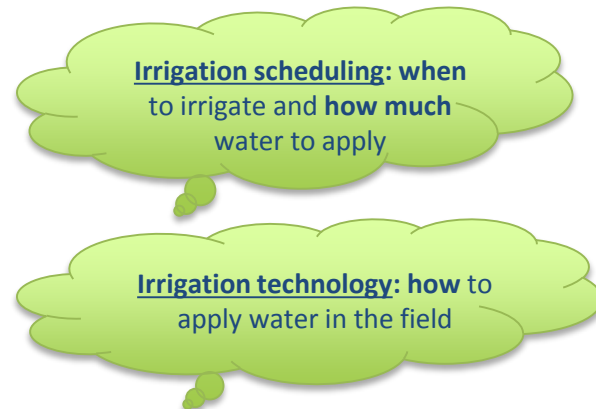


SUSTAINABLE IRRIGATION

What is it?

Sustainable irrigation aims to match water availability and water needs in quantity and quality, in space and time, at reasonable cost and with acceptable environmental income [Chartzoulakis, K., 2014]. The most important aspect is **irrigation scheduling** (when to irrigate and how much water to apply). Many parameters like crop growth stage, climatic conditions and water availability in the soil determine when to irrigate and on what frequency. Irrigation scheduling is inter-related with **irrigation technology** applied as well (how to apply water in the field).

Regarding **irrigation technology**, localized irrigation is widely recognized as one of the most efficient methods of watering crops. Localized irrigation systems (trickle or drip irrigation, micro-sprayers) apply the water to individual plants. In this way, water is applied directly into the root system under conditions of high availability, water losses are avoided and water application cost (labour) is reduced.



Irrigation scheduling forms the sole means for optimizing agricultural production and for conserving water and it is the key to improving performance and sustainability of the irrigation systems. Timing and depth criteria for irrigation scheduling can be established by using several approaches based on soil water measurements, soil water balance estimates and plant stress indicators, in combination with crop characteristics and meteorological conditions.

Limitations?

Although, various techniques and systems are available with different characteristics relative to their applicability and effectiveness, their application has been far below expectations. The main practical constraints are the high cost of such advanced systems (either for technology and/or labour), the non-economic pricing of water (price covers less than 30% of the total cost) and the technological complexity of such systems that make both technological expertise of the farmers and technical support by agriculturalists or an extension service necessary. The main behavioural constraint is that farmers awareness of water saving in irrigation is not enough and farmers do not perceive the financial and environmental benefits of such systems, or the need to commit in such investments.



KEY RECOMMENDATIONS

Sustainable and fair irrigation water pricing

The existing irrigation pricing structure in Europe varies widely both within and across countries. Tariffs and quotas are the main economic tools used, where water charging is based in the vast majority of cases on irrigated area (price per hectare applies) and rarely on volumetric usage (price per cubic meter of water consumed).

According to Water Framework Directive, Member States must design and implement steps towards the recovery of the costs of water services, that also include the financial, environmental and resource costs of water uses. Their recovery is planned to be accomplished through a water pricing system adopted in each river basin, with the aim to stimulate a more efficient use of water. As a result, the water pricing under WFD, in accordance with the polluter pays principle in particular, is expected to increase water prices, with a significant indirect impact on irrigated crops and water use expected.

Table 1: Irrigation water prices before and after WFD from various European Countries [Bruggeman et al., 2014]

	Cyprus	Greece	Italy	France	Portugal	Spain
Financial cost (€/m³)	0.34 ¹	0.005-0.115 ²				
Environm. cost (€/m³)	0.1 ¹	0-0.151 ²		-		
Resource cost (€/m³)	0.01 ¹	0-0.334 ²		-		
Cost recovery (%)	56 ¹	54 ²	50-80 (North) 10-30 (South) ³	94.8 ⁴	23 ⁴	87.1
AFTER WFD						
Irrigation water price (€/m³)	0.24 ¹	0.054-0.645 ⁵	0.01-0.80 ⁵	0.23-1.50 ⁵		
Irrigation water price (€/ha)	66.1 ¹ (base cost)		450-1705 ⁵			
BEFORE WFD						
Irrigation water price (€/m³)	0.17 ¹	0.011-0.137 ²	0.04-0.07 (South) ³		0.02 (average)	0.02 - 0.096 ⁴
Irrigation water price (€/ha)	17.1 ¹ (base cost)	90-210 ³	50-150 (North) ³ 30-100 (South) ³ 36 (average) ⁷	104 ^{4,6} (average)	120 ⁴ (average)	113 - 463.8 ⁴

¹WDD (2010);²MEPPPW (2008);³Massarutto (2003);⁴OECD (2010);⁵ENORASIS D2.1 (2012);⁶Chohin-Kuper et al., (2003);⁷ Berbel et al., (2007)

Until now, limited progress in implementation of WFD regarding water pricing has been achieved by member states. Only 49% of River Basin Management Plans have proceeded in changes in pricing.





KEY RECOMMENDATIONS

Sustainable and fair irrigation water pricing

Among policy makers and competent water and agricultural authorities, there is skepticism about the appropriate means of water pricing and also fears that the economic sustainability of a considerable proportion of small irrigated farms, in the less fertile (and water scarce) regions of South Europe will be negatively affected, if water pricing is strictly implemented [Zoumides and Zachariades, 2009].

Areas with water scarcity will experience rigorous increase in water prices, that, for some specific non-high profitable crop types cultivation, may become unaffordable. The agricultural sector of these areas is not ready to adopt these changes as until now, the low cost of water encouraged the cultivation of high-value and water-demanding crops. In past decades, also CAP subsidies have tended to favour crops with high water demands, such as maize, thus increasing the risk of water shortages under climate-uncertain conditions. [Levidow, 2012]

In these areas, the rising of water prices will be perceived as an extra penalty for the farmers/ water users and may lead to driving some of them out of business for the abovementioned reasons. So, gradually increasing of water prices is a good alternative that will give the agricultural sector the necessary time to adjust.

Another important issue to examine refers to the existing inequalities in water charging between public and private origin. Water from public systems is more often metered and charged, than private groundwater extraction that remains mostly unmonitored –as regards to water quantities-, many times even illegal. An increase of water prices at full cost only for those quantities that are currently metered and charged is unlikely to bring more efficient and sustainable irrigation water use.

From an economic, ethical and environmental perspective, private groundwater extraction needs to be fully controlled and monitored by water management authorities. [Zoumides and Zachariadis, 2009]. The illegal abstraction should be dealt by water management authorities through surveys of existing non-licensed boreholes and the closing or licensing of them, strict monitoring to avoid the emergence of new and penalization of non-authorized water activities. [ARCADIS, 2012]

Regarding the pricing scheme, volumetric pricing is considered as the most effective tariff structure with regard to actually providing incentives for water saving. Well designed volumetric tariffs have the greatest potential to fulfill cost recovery and incentive functions. Precondition is the installment of metering devices (water meters) to all users. [ARCADIS, 2012] Until now, only 40% of River Basin Management Plans of EU member states pertain measures to improve water metering [Petitguyot, T., 2014]. Water metering is also a pre-requisite for the monitoring of performance of any advanced irrigation scheduling system.

In general, water pricing policies are likely to yield more benefits if they are adjusted according to local characteristics of each agricultural region- rather than applying an one-size policy to fit all. Among measures that could be implemented, progressive, seasonal and over-consumption water tariffs as well as temporary drought surcharges rates contribute to water savings and should be promoted. Furthermore, an increasing block tariff charging system, that discourages water use levels exceeding crop's critical water requirements will be useful. It will be the basis for promoting conservation, reducing losses and mobilizing resources. [Chartzoulakis, K., 2014]



KEY RECOMMENDATIONS

Improve water conveyance and field application efficiency

The effective application of any irrigation water-saving method is subject to the physical capability of the collective system for delivering water to the farm and of the irrigation technology to apply water at the field. Many conveyance and delivery systems are unable to deliver water at the farm gates with the reliability and flexibility required, due to obsolete condition of water transport equipment, water leakages etc and need reform. This makes irrigation scheduling very difficult. Also, in surface irrigated areas supplied from collective irrigation canals, discharge and duration impose constraints to farm irrigation scheduling.

Water leakages should be detected via advanced technologies, e.g. telemetry systems, GIS, remote sensing under the responsibility of competent irrigation water management organizations. Old water projects experiencing considerable water losses should be rehabilitated and modernized.



At farm level, prerequisite for eliminating water losses is the **use of localized irrigation systems**. The more improved a localized irrigation system is (some reach more than 95% efficiency), the most improved is water productivity.



KEY RECOMMENDATIONS

Understand farmers' attitudes and perceptions regarding irrigation and organize awareness raising and promotion campaigns

The importance of farmers' decision-making process on adopting irrigation management systems has extensively been recognized in literature [Michailidis et al., 2011] and was expressed in various ways during ENORASIS project pilot activities and interactions with farmers, water management authorities, policy makers etc. By term 'adoption', the uptake of agricultural practices, usually targeted at the farmer or grower are defined. Therefore, understanding farmers' propensity or not to adopt sustainable irrigation management practices will facilitate the development of appropriate, then successful extension campaigns.

In the tables below, the most popular reasons for adopting irrigation management practices as stated in literature and from ENORASIS project results are listed

Why adopt irrigation management practices [Michailidis et al., 2011]

Why adopt irrigation management practices [ENORASIS D6.4 Pilots Assessment Report, 2014]

- ✓ Improve crop yield or quality
- ✓ Reduce energy cost
- ✓ Reduce water use
- ✓ Irrigate more land
- ✓ Other reasons (reduce labour cost, fertilizer or pesticide losses, soil erosion etc.)

- ✓ Reduce water use cost
- ✓ Reduce energy cost
- ✓ Automatization of irrigation system
- ✓ Environmental protection
- ✓ Other reasons

Policies seek to lower water usage, yet water-saving is not a priority for most farmers, who link water efficiency to maximising the farms' economic productivity, rather than saving water for environmental sustainability, i.e. they generally perceive 'irrigation efficiency' as maximising net revenue rather than saving water. Towards that aim, most farmers make irrigation decisions by relying on subjective judgements, based only on their practical experience and observation. The farmers' mindset described constraints significantly the adoption of advanced irrigation scheduling systems that research has developed. Farmers fail to perceive the potential financial benefits of these systems compared to their current practices, which they consider adequate. Ease of use and the expenses involved are also important considerations [Levidow, 2012].

Farmers' awareness of benefits in water saving in irrigation must be enhanced. This can be achieved through training and knowledge-sharing programmes that educate farmers on more water efficient practices. Also, to exploit the full technological potential of advanced irrigation scheduling systems, requires a broader dissemination of their benefits, specific training of farmers, and coupling properly-designed technological solutions with more precise operational practices to benefit farm economic performance. Otherwise, farmers will continue to perceive irrigation water high prices as an extra penalty.

KEY RECOMMENDATIONS

Communication and knowledge exchange through irrigation advisory services

Innovative high-tech irrigation scheduling systems require scientific knowledge and technical support to achieve their full potential. Farmers generally lack the means to come up with this requirements and this poses another constraint in the adoption of such innovative sustainable water management practices and methods. An interesting alternative would be to provide this knowledge and support at a more centralized level, through extension services offered by public agricultural or water management authorities or farmers' collective entities. CIMIS in California constitutes a successful example of such practice (www.cimis.water.ca.gov).

A communication and listening process between water providers, agricultural authorities, irrigation technology providers and farmers and farmers' collective entities must be established with a holistic/ integrated approach [Osann, 2014], with the aims to:

- a) Help farmers to adapt and implement viable solutions, educate, train and transfer knowledge regarding sustainable irrigation management.
- b) Support the adoption of innovative 'high-tech' irrigation scheduling systems by providing to farmers the technical and scientific advice necessary that is required to achieve the full potential of these systems.
- c) Assess end-users/ farmers needs and act as an intermediate between them and irrigation scheduling and technology research and production community.

This role may well be interpreted by an **irrigation advisory service provider of public interest or by a farmer collective entity**.



KEY RECOMMENDATIONS

Focus on end-users needs

Advanced irrigation scheduling systems are usually the result of joint research work in different scientific fields (agricultural, meteorological, hydrological, informatics etc), with focus given on accuracy of estimations rather than on ease of use.

But the perspective of farmers/ end-users is different, as they favor simplicity instead of accuracy. Farmers need simple, timely, user-friendly and affordable informative systems helpful to decide how much to irrigate in everyday practice. In the table below, the structural characteristics of European agriculture affecting technology adoption are presented. The high percentage of farmers older than 55 years old, the small farm size and the lack of agricultural training calls for simple and user-friendly solutions, easy to understand and adopt in everyday practice. Research and policy should focus on converting all scientific knowledge about irrigation scheduling in simple applications.

Table 2: Farm structural characteristics affecting technology adoption [Bruggeman et al., 2014]

	Farmers older than 55 years old (%)	Farmers with agricultural training (%)	Physical farm size (ha/farm)	Economic farm size (SO €/farm)	Gross fixed capital formation as % of GVA
Greece	55	3	5	9,267	21
Spain	55	15	24	34,525	26
France	38	50	54	98,301	29
Italy	61	11	8	30,514	34
Cyprus	63	6	3	11,809	4
Malta	57	10	1	7,652	37
Portugal	71	12	12	15,199	23
EU (27)	53	29	14	63,144	46

SO: Standard output, GVA: Gross Value Added (€)





KEY RECOMMENDATIONS

Promotion of advanced irrigation scheduling systems: Prioritize in specific target groups and target areas

Studies, pilot implementation and consultation with farmers, farmers' associations, Water Management Organizations and other stakeholders under ENORASIS project revealed that the marketing potential and subsequently the adoption of smart irrigation systems depends strongly on whether the cost of the new irrigation technology can be paid back. This is particularly important now that irrigation water prices are getting higher in Europe, under the WFD. The irrigation sector will have to pay both for the higher cost of the water and for innovative water saving technologies.

The prices of irrigation water both within and between European countries vary significantly. In that sense, **areas with relatively high irrigation water prices** would be more eager for the uptake of irrigation systems decreasing water use and costs. The same applies with **areas that suffer from water scarcity**, where sustainable irrigation technologies is a determining productivity cause. Also, **crops with relatively high market price and strong correlation between quality of yield and irrigation**, such as vineyards, orchards and vegetable crops, should be the target areas of decision makers and regulatory authorities for first adopting advanced irrigation systems for sustainable water management. [Daskalakis and Bougiouklis, 2014].

The demographic group where advanced irrigation scheduling systems appear more attractive is comprised of **young farmers, familiar with technology and with agricultural/ environmental training**. This is mainly attributed to the fact that these systems usually pertain a certain level of technical complexity and require the use of web and mobile applications.

Finally, as most of advanced decision support systems for irrigation scheduling address the needs of various stakeholders simultaneously (e.g. farmers/ irrigators, water providers etc), an interesting perspective is to prioritize and promote their **adoption from water providers (public or private) or farmers' collective entities**. In this way, the farmers will save on the initial high cost of supply and installation that for the majority of European farms is unaffordable due to their small size, and the necessary technical support will be provided on a central level.





KEY RECOMMENDATIONS

Economic incentives on sustainable irrigation management adoption by end-users

In CAP reform 2014-2020, among the number of elements that improve the interaction between agriculture and water policy, is the fact that water use efficiency and water management are addressed as sub-priorities in rural development programmes [Bidoglio, D., 2014]. In the second pillar of CAP, at least 30% of the budget of each Rural Development programme must be reserved for voluntary measures that are beneficial for the environment and climate change. These include agri-environmental climate measures which are beneficial for the environment or climate.

A basic action for farmers that should be supported with finance is the obligatory installment of localized irrigation systems and the improvement in existing ones aiming to reduce water losses, to increase the water productivity, and to prepare the ground for the adoption of more advanced water saving scheduling technologies.

Such improvements to localized irrigation systems include the use of a single drip line for a double row crop, the use of micro-sprayers in high infiltration soils, the adjustment of duration of water application and timing to soil and crop characteristics, the control of pressure and discharge variations, the use of appropriate filters to the water quality and the emitter characteristics used.

Actions that could be supported with subsidies are:

- *Installation of advanced irrigation scheduling systems (towards specific farmers' target groups and areas)*
- *Improvement of in-farm irrigation technologies.*
- *Reform of irrigation water conveyance systems.*
- *Construction of localized storage equipment for rainfall water collection*
- *Promotion, raising awareness and training campaigns for farmers and all stakeholders regarding the use of advanced irrigation technologies and scheduling systems.*
- *Capacity building of extension services for irrigation scheduling, knowledge transfer, technical support and advice on end users.*

Common Agricultural Policy financial instruments:

- *Measure 121: modernization of agricultural holdings*
- *Measure 125: infrastructure related to the development and adaptation of agriculture and forestry*
- *Measure 111: vocational training and information actions*
- *Measure 214: agri- environment payments*
- *Measure 216: non- productive instruments*





KEY RECOMMENDATIONS

Add value to green water management

Agriculture exploits both **blue water (rivers, wetlands, lakes and ground water)** and **green water (rain water and soil moisture)**, often at the same time to meet crop water requirements.

Consequently, the term 'agricultural water management' implies both:

- Technologies and practices that **make better use of available water**, that is, water saving options that help to increase water productivity (the benefit derived from each litre of water) – such as ENORASIS and other advanced irrigation systems and
- Technologies and practices which **make more water available** including water storage to cope with seasonality, increasingly variable and unpredictable rainfall, flooding, and drought. This is mainly localized storage of "green water".

Localized storage of rainfall water is a traditional, cost-effective way not to be underestimated to save water and contribute to meet crop water requirements. Its cost-effectiveness will gain importance for farmers in the next years as blue water (irrigation) prices increase. It is therefore very important to support farmers in acknowledging the importance of saving irrigation water and in building rainfall water localized storage capacity.



ABOUT ENORASIS

ENORASIS is a revolutionary smart irrigation system for farmers and water providers. It helps to monitor water use and irrigate only where and when is needed and only for as long as needed. It was developed within the **EU-FP7 funded research project ENORASIS** and it integrates the latest advances in the fields of:

- **Weather prediction systems** that exploit satellite observations.
- **Irrigation optimization techniques.**
- **Wireless sensor networks** applied in crops.

In a field that uses the **ENORASIS** system, wireless sensors compile raw data from soil moisture, air temperature, humidity, solar radiation, wind speed and gauge and water valves monitor irrigation activity. At the same time, the advanced **ENORASIS** Meteorological Analysis Tool produces a personalized daily weather forecast of rain probability, soil humidity and other parameters with a resolution of about 2km. Information from sensors, the water valves and the weather forecasts is combined once a day to generate an individual irrigation plan, that is tailored to each field and its soil characteristics to ensure maximum yield for the crop.

Farmers can receive irrigation recommendations directly on their smartphone, tablet or computer. Furthermore, water management authorities may be provided with real time information about water demand. This information helps them set water prices and estimate short and long term pressures on water reservoirs. A long term, detailed collection of valuable statistics concerning irrigation water consumption is also available for them.

An operational field prototype of the **ENORASIS** system was tested and validated for two cultivation periods at four pilot sites across Europe (**Poland, Serbia, Cyprus, Turkey**) under different crops, climatic conditions and operational approaches.

All project deliverables of public dissemination level as well as project dissemination material (leaflets, posters etc.) are available at:

www.enorasis.eu/download



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DRAXIS Environmental Technologies S.A.	www.draxis.gr	Greece
Rhenish Institute for Environmental Research, University of Cologne (RIU)	www.eurad.uni-koeln.de	Germany
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