Water Re-Use

Sustainable waste water reuse technologies for irrigated land in NIS and southern European states

Project no. 516731

WATER REUSE

Sustainable waste water recycling technologies for irrigated land in Nis and Southern European States

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DELIVERABLE 29

Executive Summary

with guidelines and recommendations for the implementation of the water saving and waste water application approaches under prevailing and foreseeable future conditions and constraints

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1. Background and rationale

Water is essential for global food, feed and fodder production. More than 8000 km^3 of water is required annually on rainfed and irrigated land to produce the food for the current world population (Rockstrom et al., 2007; Rost et al., 2008; Rost et al., 2009). The net primary productivity (NPP) is strongly water-limited in many parts of the world (Rost et al., 2010). Due to the rise of the world population, industrialization, increasing wealth in parts of the world, climate change and changing consumption patterns towards more meat and dairy products, demands on agricultural water requirements will increase in the long term (e.g. FAO, 2006a; OECD, 2010b).

Water-use projections for 2050 show that the water supply to some 47% of the world's population, mostly in developing countries, will be under severe stress, largely because of developments outside of agriculture (OECD Observer, 2010). There are doubts on the capacity of a higher efficiency of blue water[1] use or the expansion of irrigated agricultural land to meet the future demand for the production of primary biomass (e.g. FAO, 2009; Fischer, Shah and Van Veldhuizen, 2001; Rabbinge, 2007; Rockström et al., 2009). According to a recent modeling study by Rost et al. (2010), even the most ambitious and large-scale water management efforts on present cropland will not be sufficient to achieve this.

Agriculture is the major water using sector in many countries, with a global average share of 63% in total water use in 2010 compared to domestic, electricity and manufacturing (OECD Environmental Outlook Baseline, 2007). World agriculture massively wastes water through inadequate water conservation, losses in distribution and inappropriate times and rates of irrigation. A comparative study on global dimensions of agricultural water use by Sauer et al. (2010) revealed that on average, 25% of the globally withdrawn water for irrigation is actually taken up by the crops, 56% is not consumed and available for subsequent use, and 19% is unproductively lost. In some southern European regions, agriculture uses more than 80 % of the water abstracted. Farmers have shifted to water-intensive irrigation methods because of the productivity gains from policy-driven incentives and EU subsidies. In Spain, for example, the 14 % of agricultural land irrigated, yields more than 60 % of the total value of agricultural products (EC, 2010a).

Losses of water in both irrigated and rainfed agriculture are a main cause of low yields. These losses occur through the incomplete wetting of soils due to water repellency, unproductive soil evaporation due to ponding, and water loss due to runoff and throughflow, which may amount to up to 70-85% of rainfall (Rockström, 2000). Advances in knowledge and technologies during the last decades have led to considerable watersavings in many irrigated areas around the world (e.g. Siebert and Döll, 2009; Rost et al., 2010). These have often been achieved through modern water supply methodologies involving, for example, advanced drip and sprinkler irrigation. These methods, however, are costly and socio-economically not always viable, and adoption is not widespread. A crucial question for the coming decades is to what extent additional water requirements in agriculture can be minimized through a better water management.

In the European Union, a long-term imbalance due to water demand in excess of available water resources is in the making. This imbalance relates to (i) the increased demand from all sectors (agriculture, industrial, domestic & tourism), (ii) the depletion of groundwater aquifers, and (iii) the

[1] Blue water is groundwater and stream flow, supporting aquatic ecosystems, that can be tapped for use elsewhere: for domestic and stock water, irrigation, industrial and urban use (Dent and Kaufmann, 2007).

decreased effective rainfall in some parts of Europe due to climate change. The agro-climatic regions of the Atlantic south, Continental south and Mediterranean zones of Europe face the greatest risks of climate change in the form of reduced crop yields and conflicts over reduced water supply (EC, 2009). In some NI States, the ageing and lack of maintenance of irrigation systems since the ending of the Soviet Regime are still causing environmental and economic problems in irrigated agriculture (e.g. Zhovtonog et al., 2005). The most recent reports by the Intergovernmental Panel on Climate change (IPCC, 2009) conclude that "water and its availability and quality will be the main pressures on societies and the environment under climate change." The changes in demand and supply (including accessibility) cause water scarcity to become an increasingly frequent phenomenon in Europe and also in some NIS states. In addition, there are problems with deteriorating water quality, and poor management in some national water sectors (OECD, 2010a).

In summary, there is an increasing need to address problems of water scarcity and drought in the European Union and associated countries, and the policy forming community and the agricultural sectors are ready to welcome solutions. "Water is no longer the problem of a few regions, but now concerns all 500 million Europeans," claims the European Commission in its communication on water scarcity and droughts in the European Union (EC, 2010a). The challenge is to adapt, within very short periods of time, to potentially extreme impacts of changes in water supply due to climate change and water demand and due to economic development. This can best be achieved through a combination of managerial, infrastructural and technical measures. The Water Reuse project aimed at contributing to the technical measures, by developing new and advancing existing sustainable water saving strategies in the southern Mediterranean area and in NIS states. This executive summary provides an overview of these strategies.

2. Objectives and methodology

The concept of ‘water saving’ used in the Water Reuse project includes the notion that water used for irrigation benefits either evapotranspiration by (cover) crops and pasture, or the maintenance of chemical, biological and physical soil properties supporting the growth of the crops or pasture. Secondly, water saving includes the notion that less is water used for irrigation from sources that are scarce, and that are also needed for domestic and industrial purposes. The project’s objectives were:

Overall objective: To develop new, and advance existing, sustainable water saving strategies in the NIS and Mediterranean States by focusing on largely unexploited opportunities for (a) water saving and (b) use of organic-rich waste water as a non-conventional water resource on irrigated land.

Specific objective 1: Develop strategies for the exploitation and advanced management of soil wetting characteristics to counter water losses which occur through surface runoff, evaporation and uneven wetting and preferential flow in the subsoil, and

Specific objective 2: Develop strategies for the use of organic-rich municipal, agricultural and industrial waste water as an additional water resource for irrigation and nutrient source, and means for improving soil hydraulic properties and increasing medium-term carbon storage in soils.

The Water Reuse project tested the following water saving strategies in field experiments in Spain (Alicante Region), Russia (Saratov Region), Ukraine (Kharkiv Region) and Greece (Maggana Region):

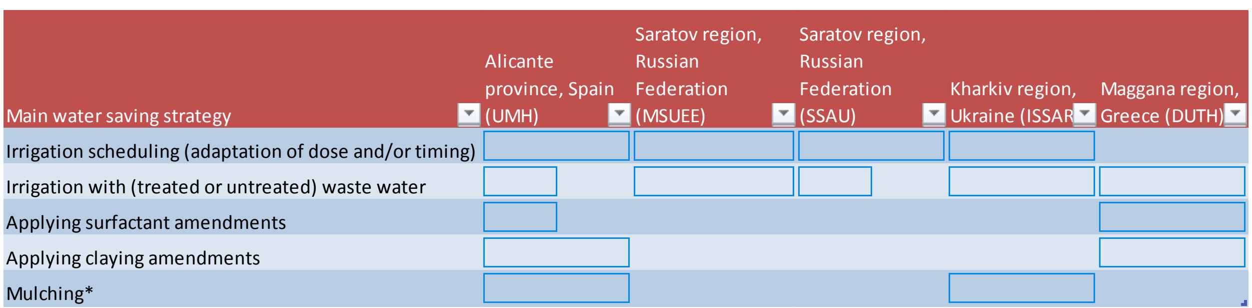
- Irrigation scheduling (adaptation of dose and/or timing)
- Irrigation with (treated or untreated) waste water
- Applying surfactant amendments
- Applying claying amendments
- Mulching

3. Overall performance of water saving strategies tested

The Water Reuse project demonstrated that there is great potential to reduce irrigation water losses in agriculture and to use waste water as a non-conventional water resource as water saving strategies. Some of these are already known and have been applied for centuries, but need reintroduction in the Mediterranean Region and NIS, such as more effective irrigation scheduling, mulching and the use of waste water for irrigation. For example, mulching is known to be capable of reducing soil evaporation by 34-50% (Sauer et al., 1996). Other strategies are based on more recent findings and need dissemination, like the use of synthesized or natural soil surfactants and claying amendments to improve the wetting characteristics of soils.

The use of (treated) waste water for irrigation was included as one of the options[2] to use non-conventional water resources in the drought sensitive study areas. The most apparent benefit of this strategy reported in the literature is that a cost-competitive and comparatively drought-proof resource is used, while the potable water supply can be conserved (Lazarova, 2005). In addition, wastewater treatment may provide environmental benefits due to the removal of pollutants, which have recently been shown to be quantifiable using CBA (Molinos-Senante et al., 2010). Wastewater as a resource is expected to be available in growing quantities in the future because a large part of the global population growth is projected to take place in cities, leading to increasing volumes of waste water generated (Scott et al., 2004). Many studies have already reported on the potential benefits of using waste water in agriculture (e.g. UNEP and UN HABITAT, 2010; Lazarova and Bahri, 2005; Scott et al., 2004).

All five water saving strategies field tested as part of the Water Reuse project showed positive effects for direct or indirect water savings in at least one test site (Figure 1).



*This strategy was added after observation of some areas experiencing loss of soil structure and high evaporative moisture loss.

Figure 1 Visual summary of results of water saving strategies field tested in the Water Re-use project. Length of orange bars indicates strength of positive effect. Blank cells denote applications that were not tested in the Water Reuse project.

Adjustment of irrigation practices to match real time agronomic conditions can be considered the top ranking water saving strategy as it can, with minimal investment, be immediately applied wherever irrigation is presently practiced. Results indicate that this strategy, especially when employed using information from the SWAP model[3] and moisture sensors to determine dose, timing and intensity can significantly increase irrigation efficiency through more effective delivery of water to soil depths accessible for plant growth. These results contribute to water savings by increasing the effective delivery of water to the root zone and reducing unproductive losses of water such as runoff, irregular wetting

[2] Other options include grey water or rainwater harvesting (e.g. EEA, 2009).

[3] Soil, Water, Atmosphere and Plant Model (www.alterra.swap.nl)

and deep percolation. It is strongly recommended that this strategy, informed with site and crop specific information, be promoted as an important water saving strategy. In addition it is recommended that further information on crop growth cycle with respect to rooting depth and moisture requirements be developed to further refine the strategy of irrigation scheduling.

Use of treated waste water has the potential to directly reduce demand on fresh water for irrigation and ranks high as a strategy. In general, the water saving strategies using waste water tested over a 2-3 year period in the Water Reuse project did not result in significant differences in soil water repellency, soil salinity, soil alkalinity, soil organic matter content and heavy metal content compared to traditional irrigation techniques using fresh water. This implies that the use of waste water under the conditions tested in the project does not necessarily induce harmful effects of the release of residual loads into the environment, as is often reported in the literature for waste water use in agriculture (e.g. Scott et al., 2004; Lazarova and Bahri, 2005; Muñoz et al., 2009; Fatta-Kassinos et al., 2010).Based on the results from the partner in Greece, irrigation with treated waste water may help manage soil wettability in already water repellent soils. Results also indicate, however, that the water quality and crop sensitivity to irrigation water salinity are important factors in employment of this strategy.It is strongly recommended that available wastewater be considered for irrigation – especially where the wastewater is consistent in quality, available through the duration of the local growing season, and crops are not salt sensitive. In addition, monitoring of soil wettability is recommended as waste water quality (including organic content) and soil moisture levels are contributing factors to the development of water repellency, suggesting that the positive results of these trials may not be universally true.Apart from the pollution parameters assessed in the Water Reuse Project, during the last decade, due to industrial and technological advances a number of additional chemical contaminants persisting in municipal waste water after conventional treatment require attention for the safe use of wastewater in irrigated agriculture. These include xenobiotic compounds, pharmaceuticals and personal care products, drugs' metabolites, illicit drugs, transformation products, and also genes resistant to antibiotics. Additional research is required to increase the knowledge on the identification, fate and effects of these substances on humans, non-target organisms and the environment when wastewater is used in irrigated agriculture.

For agricultural areas with problems with soil wetting, management of soil wetting characteristics with surfactant and/or claying amendments ranks very high. Results indicate that, when soil water repellency is interfering with wetting of soils and full use of soil water retention ability, application of surfactant amendments is an effective strategy for improving soil wetting and moisture content in the root zone. The commercial soil surfactant tested was more effective for immediate results. The olive mill wastewater solution tested had a more gradual, but still significantly effective, impact. It is recommended that the application of soil surfactant amendments be considered for management of soil wetting characteristics whenever there is evidence of soil water repellency which is indicated by less than ideal wetting of the soil. For immediate improvement of soil wetting, a proven, environmentally benign commercial soil surfactant would be recommended, since this can reduce water consumption and stimulate crop yield (Moore et al., 2010). Where supplies and handling requirements are available, and a gradual impact is acceptable, use of diluted olive mill wastewater can also be recommended based on the results of these trials. Continued research on the ability of soil surfactant amendments to improve water distribution in soils is encouraged, as well as investigation of combination programs using commercial surfactant and olive mill wastewater, and investigation of approaches combining use of surfactants and application of claying amendments.

The strategy of applying claying amendments for management of soil wetting characteristics through reduction of soil water repellency was effective in both the laboratory and field trials conducted. In Spain, previously tested methods were used in laboratory studies and reveal that water repellency can be nearly completely reduced with sufficient quantities of kaolinite clay incorporated into the top 5 cm of the soil (approximately 8.5 tons/ hectare for the soil tested). In Greece a regionally available clayey soil was used applied, at a rate of 1 Kg/m2, by a novel “wet clay” suspension method or incorporated dry. These trials revealed that dry incorporation of this particular material was not very effective, however the “wet clay” approach resulted in significant reduction of water repellency. It is recommended that, where soil water repellency occurs, application of claying amendments is a strategy to consider if the supply and means of effective incorporation are available. Areas for further research include more trials with the novel “wet clay” method using locally available clayey soils, and potential benefits of combining the application of claying amendments with the use of surfactants.

Mulching in combination with other strategies, such as modification of irrigation scheduling and use of treated waste water, diminished observed negative impacts on aggregate stability by lessening the impact of irrigation on the soil surface and avoiding severe wet dry cycles, and reduced water losses to both evaporation and preferential flow. In Ukraine mulching appears to have contributed to an increase in yield by allowing more water to be retained in the upper regions of the soil. Results indicate, especially where irrigation of bare soil results in loss of aggregate stability and high evaporation, that mulching contributes to better management of soil wetting characteristics and reductions in unproductive losses such as evaporation and preferential flow. It is recommended that mulching be considered where bare soil may increase susceptibility to damaging soil aggregate stability and excessive evaporation. Soil wetting behavior may be positively managed under these conditions, as well as a complimentary effect on other water saving strategies. It is also recommended that additional research be conducted on the impact of mulching practices on water retention and availability to determine if the moisture is plant available and therefore the impact of mulching practices on water use efficiency.

In all cases there are potential compatibilities between the tested strategies. For example, mulching in combination with irrigation using waste water showed to be particularly efficient. Investigation of these compatibilities is recommended for optimization of sustainable water saving strategies to reduce the impact of agriculture on water resources. Combinations with other technologies, like solar-powered irrigation (PVDI) (Burney et al., 2010), may provide options to improve water and food security in areas with rain fed agriculture.

More details of the research results can be found in **Deliverable 25**. More detailed outcomes as regards biophysical and socio-economic issues are summarized in the following two sections.

4. Water saving strategies related to biophysical conditions

Several problems in sustainable land and water management motivate the (re)introduction of water saving strategies in the regions in the NIS and Mediterranean investigated in the Water Reuse project. These problems partly relate to biophysical conditions related to soil and water, and land management. According to an inventory by the research teams and consulted land users, the most important problems in these three categories are respectively salinization, the scarcity of fresh water, and low crop productivity. Problems due to soil salinization are most prominent in the study regions in Russia, where it is heritage of irrigation in past decades, which caused groundwater levels to rise. These conditions motivate irrigation scheduling in order to prevent percolation of irrigation water from the root zone to the groundwater. This was demonstrated successfully for the research sites in Spain, Russia and Ukraine. The use of wastewater, if controlled for salinity, was shown to provide an alternative resource for irrigation to saline groundwater without negative effects on soils and crops in the research sites in Russia, Ukraine and Greece.

Fresh water resources are scarce in all studied regions. In Spain this is due to the scarce surface water resources and the overexploitation of aquifers. In Greece and Russia groundwater is available even at shallow depth, but the quality is bad due to the use of saline water for irrigation in previous periods, or due to sea water intrusion. The unawareness of farmers of the effects of unlimited irrigation with saline water also contributes to the water scarcity problems in Greece. In Greece, Russia and Ukraine fresh water resources from surface water are at long distance from farmers' fields. The main climatic conditions inducing fresh water scarcity in the study regions include the rainfall deficit in the summer growing season. Soil conditions inducing water scarcity include the sensitivity to structural decay and consequent reduced infiltration due to drop impact from rainfall and sprinkler irrigation in Ukraine, and the water repellent nature of the coarse, sandy topsoils in the Greek study region, leading to reduced infiltration. Socio-economic conditions leading to water scarcity in the study regions include the unavailability of irrigation system infrastructure at short distance and the cost-benefit ratio of irrigated agriculture. Also, in Russia, water scarcity is maintained because farmers are not stimulated to modernize irrigation techniques and to increase the efficiency of irrigation in agriculture. This is induced by the regional policy, which subsidizes the energy used for the transport of water from the Volga River to fields. The use of wastewater for irrigation provides a logical water saving strategy in response to the mentioned problems of water scarcity, since treated waste water is increasingly available in the studied regions year-round at shorter distance to agricultural areas than fresh water resources in parts of the study regions. The use of wastewater for irrigation may be supplemented with irrigation scheduling, mulching and amendments with clay or surfactant to improve the water use efficiency of crops and/or the wetting properties of the soil surface and topsoil, as was shown for all study regions. The availability of wastewater and possibilities for treatment were outside the scope of the Water Reuse project, but would require further research for a more detailed assessment of the benefits of wastewater irrigation in response to the problems of water scarcity in the studied regions.

Problems with low crop productivity motivating the introduction of water saving strategies are partly related to soil conditions, and partly to land management and economic conditions. The soil conditions refer to the inhomogeneous permeability of fields in Saratov region. The land management conditions refer to the sub-optimal application of crop rotations and practices related to tillage, weeding, and the insufficient use of fertilizers and pesticides, which is the case in the study region in Ukraine. Low crop productivity is not so much of a problem in the Spanish study region. In the study region in Ukraine, the lack of credits and resources (fertilizers and equipment) are responsible for low crop productivity. In the study region in Greece, the revenues from crop yields are considered low by land users due to the low crop prices. Water saving strategies like irrigation scheduling, mulching and amendments of clay or surfactant help to homogenize the wettability of soils under crops or grass covers, as was shown for the experimental sites in Russia and Greece. The use of nutrient-rich wastewater for irrigation was shown to solve nutrient deficiencies by improving crop yields in the research site in Ukraine.

The biophysical conditions influencing the applicability of the water saving strategies investigated in the Water Reuse project include land use and terrain conditions, soil characteristics, agro-climatic conditions and water-related conditions. Of the biophysical conditions relevant to the implementation of water saving strategies, agro-climatic conditions and soil texture, soil fertility and topsoil organic matter content were considered important in all environmental settings of the study regions by researchers and land users. Detailed information on the relevance of biophysical conditions for water saving strategies is given in **deliverable 26.**

The results of the field experiments of the water saving strategies in the Water Reuse project showed that the combinations of land use and terrain conditions, soil characteristics, agro-climatic conditions and water-related conditions in the studied regions in Spain, Russia, Ukraine and Greece were generally favorable to support the objectives of the Water Reuse project to better employ soil wetting characteristics and reduce irrigation water losses, and to use wastewater as an alternative resource for irrigation. Several areas offering scope for applying the tested strategies based on biophysical conditions were identified. Based on the findings of the project, recommendations were given for the implementation of the tested water saving strategies dependent on biophysical conditions similar to the conditions prevailing in the studied regions in Spain, Russia, Ukraine and Greece.

5. Water saving strategies related to economic and socio-cultural conditions

The performance of water saving strategies depends on economic, ecological and socio-cultural valuations of the techniques by stakeholders (e.g. Lazarova, 2005). Information on economic and socio-cultural indicators of the performance of water saving strategies is essential to evaluate their performance from a viewpoint of efficiency and competitiveness in sustainable land and water management. The Water Reuse project provided information on the demographic context of the study sites, types of land users, land ownership, land and water use rights, access to services and infrastructure, agricultural production systems and water supply in the studied regions. Below, the main outcomes are summarized. Detailed information on economic and socio-cultural conditions can be found in **Deliverable 27**.

Land users likely to apply water saving strategies belong mostly to the average wealth category, and manage a large part of the agricultural land area. This offers good perspectives for initiatives to introduce water saving strategies in regions similar to the ones tested. Land ownership (or the type of land possession) varies widely between the study regions, indicating that the introduction of water saving strategies must be fine-tuned to address many different land owners.

The project identified the need for better communication and dissemination of experimental evidence of increased water use efficiency and production from using water saving strategies to land users, in order to increase the likelihood of adoption of these strategies. This applies specifically to the use of wastewater for irrigated agriculture, since the legislative mechanisms of recycling and using wastewater on private land are not or partly established, and there is a general mistrust of the populations to the use of wastewater due to lack of informedness of the effects on crops, environment and human health. The experimental results from the Water Reuse project may be used in a communication effort to create awareness on the strengths and weaknesses of water saving strategies.

In countries where water rights are (partly) unorganized, the project recommends regional authorities to consider the organization of water rights in water management programs. This could be done through subsidies or pricing mechanisms. In none of the studied countries water saving strategies are currently subsidized. In contrast, for example in Spain, subsidies for the production of agricultural commodities stimulate the use of irrigation water, with potential negative effects on the availability of fresh water for other purposes than agriculture. In this way, subsidies may become harmful for the environment (Environmentally Harmful Subsidies, Valsecchi et al., 2009). In the Russian Federation, regional subsidies for energy to transport irrigation water over large distances are not encouraging farmers to modernize irrigation techniques.

The Water Reuse project showed that stakeholders are moderately to highly sensitive to financial incentives for the introduction of water saving strategies in the studied regions. The recent economic crisis and governmental recovery plans provide an opportunity to reform EHS and to introduce subsidies on water saving strategies. In addition, the discussion on the Europe 2020 strategy, the successor of the Lisbon strategy and the review of the EU Sustainable Strategy could provide more opportunities. Apart from subsidies, for those strategies requiring infrastructure to cover large-scale production units, the initiative, investment and involvement of the state or decentralized governments is indispensable for the implementation of water saving strategies.

Of the stakeholder groups identified in the study areas as possibly relevant for the adoption of water saving strategies in the study areas, agricultural advisors and consultants, land users, farmers organizations, owners of agricultural land and water authorities were identified as very influential. The impact of policy makers is very different between the regions, and should be taken into account in the development of policy frameworks addressing water scarcity in the regions. A restricted stakeholder consultation provided information on stakeholder assignments of importance to economic, environmental and socio-cultural indicators of water saving strategies. Stakeholders in the studied regions appeared to assign a large importance to the extent of legal restrictions, education and training of land users, the acceptability of using waste water for irrigation, and farmer health and safety. Also, political and financial incentives were considered important to enable the adoption of water saving strategies. This information could be used to identify suitable areas in the NIS and Mediterranean in action and learning initiatives for sustainable water management in these regions. An example of the use of this information was demonstrated in a multi-criteria analysis of the performance of the tested water saving strategies in the Spanish study region, based on field experimental results and the stakeholder consultation.

6. Recommendations for policy

This project provided insight in the effectiveness and competitiveness of several water saving strategies to be applied at a range of spatial scales, from small fields to large-scale agricultural production zones. The results are placed in the contexts of the biophysical and socio-economic environments of the studied regions. In order to use these results in sound water management programs for agriculture with the objectives to reduce irrigation water losses and to use waste water as an alternative source, the following recommendations for policy frameworks and mechanisms are made.

In the first place it should be noticed that the results of the Water Reuse project were obtained in short-term (2-3 year) field experiments, whereas for policy development, insights in economic and environmental effects on the long term are required. This applies particularly to the unknown effects of the use of wastewater from different sources and qualities on soils and groundwater in the longer term (see also section 3 on pollution parameters of wastewater use), and to the development of soil wettability under the prolonged use of industrial surfactants. Therefore it is recommended to investigate resources in long-term research programs on (existing) experimental farms in regions covering the range of biophysical conditions and wastewater qualities of interest, in order to build reliable records of long-term effects.

Several policy frameworks may help to facilitate the introduction of water saving strategies. The revision of the Common Agricultural Policy (CAP) after 2013 may help to facilitate the introduction of water saving strategies in agriculture (e.g. OECD, 2010b). The revision of the CAP is likely to entail a transition from income support to agricultural enterprises and subsidies linked to production volumes towards payments for societal achievements by agricultural land users. Sustainable water management related to agricultural land use is mentioned as one of the important societal achievements in this revision of the CAP. The water saving strategies tested in the Water Reuse project could form part of such societal achievements. The education and training of farmers was rated by stakeholders as one of the most important factors enabling the adoption of water saving strategies in the regions in the Mediterranean and NIS studied. In order to disseminate the knowledge on water saving strategies cumulated in this and other projects, and to encourage the adoption of water saving strategies, the Farm Advisory System[4] could be used.

In addition to the existing and future mechanisms offered by the CAP, other mechanisms should also be considered to stimulate and facilitate the adoption of water saving strategies. These include the reduction of legal restrictions for the application of waste water use in agriculture, insurance, capacity building, networks and partnerships, some of which are currently also suggested for adaptation to climate change in the agricultural sector (AEA, 2007).

The legislative act that provides the framework for water regulation in Europe is the Water Framework Directive (60/2000) (WFD). The WFD has a basin approach to water management, centered on the review of River Basin Management Plans every 6 years. Planning measures addressing drought is part of this system. In that viewpoint, water saving strategies like those proposed in the Water Reuse project may be proposed to become part of river basin management plans. The selection and performance evaluation of water saving strategies could be evaluated using instruments like the SPIDER system developed in the EU-funded PLEIADeS project.

[4] System to be established by the EU Member States to advise farmers on land and farm management and to help farmers to face their obligations under the Cross-Compliance standards of the CAP (http://ec.europa.eu/environment/ppps/pdf/fas.pdf).

Water pricing is one of the options identified for more sustainable water management in the European Union and NIS states (OECD, 2010a,b; EU, 2010b). Indeed the need to consider water as an economic good becomes vital with growing competition between economic sectors for adequate water resources and augmenting problems of water scarcity. Global modeling studies demonstrate that substantial price adjustments for water are required in response to increased demand for food and economic development (e.g. Sauer et al., 2010; OECD, 2010a). The findings of the Water Reuse project confirm that current water prices in the studies countries are not limiting the use of fresh water in irrigated agriculture in the studied regions. The WFD emphasizes the role of economic instruments in water policy, and will introduce water pricing in 2010 acting as an incentive for the sustainable use of water resources and helping to reduce unnecessary consumption (EU, 2010b). Stimulating the implementation of water saving strategies trialed in the Water Reuse project may help to reduce the economic consequences of more restrictive water pricing for agricultural enterprises.

7. Products from the Water Reuse project

Apart from the results summarized in this overview, the Water Reuse project delivered some tangible products supporting the objective to develop sustainable water saving strategies in the NIS and Mediterranean States, focused on increasing water use efficiency and using wastewater as an alternative source. These include:

- An on-line database of the field experimental results and performance on key indicators of performance of the tested water saving strategies. The database includes information on the set-up of the field experiments, including characteristics of soils, water used and of the water saving strategies. In addition, quantitative data are provided on the performance of the strategies on economic and environmental indicators, like the crop yield, irrigation use efficiency, soil water repellency, heavy metal contents of the soil, soil alkalinity, salinity and organic matter contents.

- A series of 14 colored bulletins in non-scientific language describing the most successful strategies found in the project, available in English and translated into Spanish, Russian, Ukrainian and Greece.

- A suite of dissemination products including the Water Reuse project website, scientific papers, congress contributions, newspaper articles and broadcast media presentations. These products are listed in **Deliverable 30.**

All products are accessible from the project website at www.waterreuse.eu.

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