European Commission

EU-level instruments on water reuse

Final report to support the Commission's Impact Assessment

Prepared by
Amec Foster Wheeler Environment
& Infrastructure UK Ltd, IEEP, ACTeon, IMDEA and NTUA

October 2016

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Luxembourg: Publications Office of the European Union, 2016

ISBN 978-92-79-62616-6
doi:10.2779/974903

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Issued by: Victoria Cherrier

Authorised by: Nick Jarritt

No.	Details	Date
1	Draft Impact Assessment report	27 May 2016
2	Draft Impact Assessment report (revised)	13 June 2016
3	Final Impact Assessment report	24 August 2016
4	Final Impact Assessment report (revised) 16380i1	28 September 2016
5	Final Impact Assessment report (revised) 16380i2	05 October 2016

Prepared by Amec Foster Wheeler Environment & Infrastructure UK Ltd and IEEP, ACTeon, IMDEA and NTUA

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1. Project understanding

1.1 This report

Amec Foster Wheeler Environment and Infrastructure UK Limited ('Amec Foster Wheeler') has been contracted by the European Commission to undertake a study on the development of EU-level instrument(s) on water reuse (specific contract 070201/2014/SFRA/689105/ENV.C1). Our project team consists of Amec Foster Wheeler, IEEP, ACTeon, NTUA and IMDEA. IEEP has taken the overall lead for this project, however Amec Foster Wheeler has led the delivery of Task 1 to which this report relates.

This report presents the deliverable under Task 1 and is intended to support the impact assessment of the policy options identified by the European Commission. This report was updated to take into account comments received following consultation of the Common Implementation Strategy Ad-hoc Task Group on water reuse. This report is a follow-up to the initial support report delivered by BIO (BIO, 2015). The policy options have been defined in accordance with the Inception Impact Assessment[1] published by the European Commission and the impacts are assessed against a simplified (and now superseded) version of a draft proposal developed by the JRC on 'Development of minimum quality requirements at EU level for water reuse in agricultural irrigation and aquifer recharge'[2] (hereinafter as minimum quality requirements considered in the IA).

The content of this report could be used as one source of information by the European Commission to produce the Impact Assessment report should it decide to go forward with making a legislative proposal based on the updated proposal of the EU (JRC). However, further work would be needed in order to update the review of the economics, environmental and social impacts of the final proposal of the EU which is not yet available.

1.2 Project objectives

The aims of the project are to "provide independent, sound and timely advice on the completion of the impact assessment of policy options to be developed in the context of water reuse". As part of the development of the project, the original tasks and timing of this project were revised to include an additional task aimed at the collection of evidence on the possible impacts of the actions included in the water reuse policy fiche of the Commission[3]. The evidence collected on the actions of the water reuse policy fiche were presented in the intermediate report. The latter stage of the project focused on providing evidence to support the impact assessment of the development of a legislative proposal setting minimum requirements for water reuse for irrigation and aquifer recharge.

The revised tasks of this project are as follows:

- Under Task 1:
  - Gather additional evidence for the actions included in the water reuse policy fiche to provide the Commission with relevant information; and
  - Support the Commission with the development of a follow-up report to support the Impact Assessment of a legislative proposal setting minimum requirements for reused water for irrigation and groundwater recharge, in line with the most recent Commission guidelines on Impact Assessment.
- Under Task 2, the project team supported the Commission with the development of CIS Guidelines on Integrating Water Reuse in Water Planning and Management in the context of the

1 http://ec.europa.eu/smart-regulation/roadmaps/docs/2017_env_006_water_reuse_instrument_en.pdf
2 Version of April 2016, now superseded
3 The reuse actions are presented at: http://ec.europa.eu/environment/water/reuse-actions.htm

WFD. This document has now been finalised and was endorsed by EU Water Directors on 10 June 2016[4].

1.3 Evidence used in the study

This study to support the Commission's impact assessment has been conducted taking into account to the Better Regulation guidelines[5], and the Better Regulation toolbox, in particular Chapters 2 and 3 of the toolbox concerning the identification and assessment of impacts.

The previous report to support the impact assessment conducted by BIO, and the results of a public consultation[6] constituted an important source of evidence for this follow-up work[7]. Where feasible the information and data quoted has been cross-checked with publicly available references. This project also involved collection of additional quantitative information by developing case studies of selected Member States. Additional literature was also consulted and used to support the evidence base.

Finally, the Inception Impact Assessment published by the European Commission[8] has been used as a reference.

1.4 Terminology

"Water reuse" refers to the production of water through water treatment processes which introduces a feedback loop in the water cycle. As such, water reuse is not an additional water source but rather a product that needs to be tailored to the intended uses. It differs to supply augmentation measures such as sea-water desalination, which in effect includes a new input to the water cycle.

Currently there is a range of terminology and definitions used to define water reuse within Member States and globally: water reuse, water recycling, treated wastewater reuse and reclaimed water are all used interchangeably which has resulted in confusion between and within different countries (EPA, 2012). Water reuse systems can have different quality standards reached by means of different treatments depending on the use foreseen.

A range of definitions used for water reuse are outlined in the box below. Only a limited number of actual definitions were found from the literature review.

Definitions of Water Reuse

Urban Waste Water Treatment Directive
The Urban Waste Water Treatment Directive (UWWTD) does not include a definition of 'water reuse', though Article 12 states that 'treated waste water shall be reused whenever appropriate'.

CIS guidelines on water reuse[9]
Water reuse is the use of water which is generated from wastewater or any other marginal water and treated to a standard that is appropriate for its intended use.

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[4] Common implementation strategy for the Water Framework Directive and the Floods Directive, Guidelines on Integrating Water Reuse into Water Planning and Management in the context of the WFD, 10th June 2016

[5] European Commission, SWD(2015)111, Better regulation guidelines http://ec.europa.eu/smart-regulation/guidelines/docs/swd_br_guidelines_en.pdf

[6] The public consultation received a total of 506 responses among which 224 were individual responses, 222 were companies (with half being large companies and the other half being SMEs) and 43 were public authorities. Respondents from France, Spain, Italy and Germany constituted 65% of the total responses.

[7] BIO (2015) Optimising water reuse in the EU, Final report – Part I, Prepared for the European Commission – DG ENV and BIO, 2015, Public consultation report on optimising water reuse

[8] Inception impact assessment, available at: http://ec.europa.eu/smart-regulation/roadmaps/docs/2017_env_006_water_reuse_instrument_en.pdf

[9] Common implementation strategy for the Water Framework Directive and the Floods Directive, Guidelines on Integrating Water Reuse into Water Planning and Management in the context of the WFD, 10th June 2016

International Standardization Organisation (ISO)[10]
The ISO 6075-1:2014 'Guidelines for treated wastewater use for irrigation projects' defines water reuse as "the use of treated wastewater for beneficial use", where waste water is "wastewater collected principally by municipalities that can include spent or used water from domestic, institutional, commercial, or industrial sources and can include storm water".

Recycled Water in Australia[11]
In Australia, water recycling is the generic term used for water reuse. It is defined as "water taken from any waste (effluent) stream and treated to a level suitable for further use, where it is used safely and sustainably for beneficial purposes. This is a general term that can include reclaimed water**".**

US Environment Protection Agency (US EPA)[12]
The US EPA considered reclaimed water which is municipal wastewater treated to a specific water quality criteria so it can be beneficially reused. The EPA distinguishes the following categories:

- De facto reuse: A situation where reuse of treated wastewater is, in fact, practiced but is not officially recognized (e.g., a drinking water supply intake located downstream from a wastewater treatment plant [WWTP] discharge point);
- Direct potable reuse (DPR): The introduction of reclaimed water (with or without retention in an engineered storage buffer) directly into a drinking water treatment plant, either co-located or remote from the advanced wastewater treatment system;
- Indirect potable reuse (IPR): Augmentation of a drinking water source (surface or groundwater) with reclaimed water followed by an environmental buffer that precedes drinking water treatment;
- Non potable reuse: All water reuse applications that do not involve potable reuse; and
- Potable reuse: Planned augmentation of a drinking water supply with reclaimed water.

Global Water Research Coalition[13]
In its research on 'Status and Role of Water Reuse' the Global Water Research Coalition used the following definitions for water reuse and reclaimed water:

- Reclaimed water: treated municipal wastewater and other impaired waters that are used for beneficial purposes;
- Water reuse: the use of reclaimed water for any purpose;
- Indirect potable reuse: augmentation of a raw water supply with reclaimed water followed by an environmental buffer. The mix typically receives additional treatment before distribution as drinking water. The definition of indirect potable reuse could be further broken down to "planned indirect potable reuse" (i.e., discharge of reclaimed water to a drinking water source with the intended purpose of augmenting the potable supply) or "unplanned indirect potable reuse" (i.e., discharge of treated wastewater to a drinking water source as a disposal method rather than as a purposeful means of augmenting a potable water supply.); and
- Direct potable reuse: introduction of reclaimed water directly into a water distribution system, without intervening storage (pipe-to-pipe).

The UWWTD does not define 'water reuse' however Article 12 encourages the reuse of treated waste water where appropriate. It defines urban waste water as 'domestic waste water or the mixture of domestic waste water with industrial waste water and / or run-off rain water'.

This report uses the UWWTD definition in order to define its scope. For the purpose of this report, and in agreement with the definition used in the CIS guidelines, 'water reuse' is defined as "*reuse of urban wastewater that is treated after collection, having been subject to appropriate treatment"*. **The source of water to be reused is only the wastewater covered by the Urban Wastewater Treatment Directive (91/271/EEC), that is to say urban wastewater and industrial wastewater from the industrial sectors listed in Annex III of the UWWTD**. Adequate treatment is to be understood in agreement with the UWWTD as 'treatment of urban waste water by any process and/or disposals system which after discharge allows the receiving waters to meet the relevant quality objectives and the relevant provisions' of the EU legislation. This report does not use terms such as 'tertiary treatment', 'polished' or 'finished' as they would not necessarily clarify the level of treatment appropriate to the particular use.

The reuse of rainwater and grey water are not included under the scope of this report. A previous study conducted by BIO in 2012 concluded that EU policy on certification to promote rainwater harvesting and reuse in buildings could achieve a 5% reduction in potable water use by 2050 but would be applicable only for major renovation or new buildings. For both rainwater and grey water, the conclusions were that EU

[10] ISO/FDIS/16075-1 Guidelines for treated wastewater use for irrigation projects — Part 1:The basis of a reuse project for irrigation
[11] Recycled water in Australia (nd) http://www.recycledwater.com.au/index.php?id=90
[12] EPA (2012) Guidelines on water reuse
[13] Global Water Research, water reuse definition. http://www.watereuse.org/files/images/04-007-01.pdf

policy instruments related to eco-design of buildings are considered to be more suitable than water policy instruments[14].

Finally, industrial waste water is not included under the scope of this report. Water use and reuse is addressed in specific Best Available Techniques Reference Documents (BREFs) and additional information gathered indicated that industrial reuse would be best addressed through these BREFs.

It should be noted that the Guidelines produced under Task 2 include definitions relevant to water reuse. The definitions included there are specific to those Guidelines (to facilitate understanding) and are not presented for use elsewhere.

[14] BIO, 2015, Optimising water reuse in the EU, Final report – Part I, Prepared for the European Commission

2. Water reuse and EU policy context

2.1 Risks and benefits of water reuse

Water reuse presents environmental, economic and social benefits but also potential drawbacks. The risks presented by water reuse have to be addressed in order to ensure health and environment safety. The CIS guidelines on integrating water reuse in water management identified several of the key potential benefits and risks to address in order to engage in safe water reuse, these are summarised below[15].

Environmental benefits

- Water reuse can increase the natural and artificial flow in streams and ponds, helping to meet the quantitative objectives of surface water bodies. Restoration of streams, wetlands and ponds using water reuse has been found to be effective in some cases, leading to the revival of aquatic ecosystems;
- Water reuse to recharge aquifers can help in meeting good quantitative status and avoiding deterioration in the status of groundwater if it can be ensured that the chemical status is not adversely affected;
- Wastewater treatment plants in coastal areas, including in water scarce regions, often discharge their treated effluents into the sea, which leads to a wastage of freshwater resources. Water reuse means that this water is conserved, allowing for better resilience to changes in demand triggered by population changes but also climate change;
- In water-scarce areas, water reuse provides an alternative source, thus enhancing the availability of water and the stability of the water supply;
- In water stressed countries, water reuse may present a lower environmental impact than other alternative water supplies such as desalination;
- In some cases, water reuse can reduce the need for artificial fertilisers by providing nutrients for irrigation; and
- Planned water reuse reduces the risks to the environment and human health that can be created by unplanned reuse.

Risks to health and the environment

- Untreated wastewater contains polluting substances and organisms that can pose a risk for both human health and the environment. The presence of these substances and organisms is reduced through treatment, in particular secondary treatment, but additional treatment may be necessary to provide water safe for reuse. Some of the substances are already regulated under EU legislation, and it is important that water used for reuse does not lead to the non-implementation of this legislation (e.g. the EQS Directive[16]);
- If water has not been appropriately treated before being reused, both the environment and people can be exposed to pathogens and substances through spraying during irrigation, direct contact with the water or the consumption of unwashed / uncooked crops on which the pathogens may occur. Through time, substances can accumulate in the soils or in groundwater leading to environmental deterioration;
- While treatment and the appropriate management of water can provide safe water to reuse, it is important to understand and assess the risk to ensure the safety of the population and the

[15] CIS guidelines, June 2016,

[16] Directive 2008/105/EC on Environmental Quality Standards

environment. Substances that may be present in water are very heterogeneous with different retention, depletion and behaviour when infiltrating the soil. Some substances are more persistent than others and for some substances (including micro-pollutants) there is much that remains unknown about health and environmental risks;

- In order to control risks posed by water reuse, and in addition to the quality of the treated wastewater, factors such as the quality of the receiving water, the depth of the water table and vadose zone (for aquifer recharge) and soil drainage (for irrigation) should be considered;
- Reuse may be beneficial in terms of preventing secondary effluent discharges to the environment. However, it is also important to consider whether the discharges were contributing to maintaining flows of water bodies to avoid unexpected negative impacts on the environment; and
- Where reclaimed water is disinfected with chlorine, a potential negative effect of water reuse is the discharge of residues from the chlorine treatment into the environment, which may harm aquatic systems.

Economic benefits

- Water is a resource. As such avoiding the loss of that resource can deliver economic benefits;
- Water reuse may encourage a more appropriate pricing of water which in turn could create incentives to reduce water demand;
- Water reuse can have a positive impact on land value, as it may allow land located in water-stressed areas to be developed / used. When used for irrigation, water reuse can encourage more productive agriculture; and
- The water reuse sector can promote an innovative and dynamic water reuse industry with increased competitiveness and can stimulate innovation.

Economic risks

- Water reuse is seen as a costly option with low returns on investment in particular when compared to abstraction from water bodies. Many schemes have benefited from direct or indirect subsidy to support the supply and demand of water reuse, which may need further consideration, in particular when considering the need for cost recovery and financial sustainability in the water sector. However, it is important to note that the cost of conventional water resources is often also subsidised or kept low (especially for irrigation); and
- The infrastructure costs for a reuse scheme, including treatment works, water distribution systems and irrigation systems may need financing and the economic viability of such projects will depend on the specific situation.

Social benefits

- The increased economic activities made possible with water reuse would in turn lead to social benefits such as employment. In particular, for countries with important tourism industries, water reuse would indirectly support the development of tourism by allowing the development of water-related activities such as golf courses, parks or hotels;
- Water reuse could improve food security by providing an alternative source for irrigation and in turn support rural communities and businesses; and
- Water reuse could also encourage a more integrated approach to water management, considering both drinking water and wastewater together.

Social risks

- In some countries, the public perception of water reuse can be negative and there may be a distrust of water reuse practices.

2.2 EU policy context on water reuse

This project reflects the recognised need to increase uptake of alternative options regarding water resources allocated to urban, agricultural, and industrial water users across Europe.

Article 5 of the Water Framework Directive requires an analysis of pressures on water bodies. Over-abstraction of water from surface and groundwater bodies is a significant pressure in some areas of Europe and may be driven by wider problems of scarce water resources and increased by climate change. Where over-abstraction is identified as being a significant pressure (as per Article 5 analysis of pressures), Member States should adopt appropriate measures to reduce the existing pressures and to prevent predicted pressures (as a means of climate change adaptation) in order to achieve good status of surface and groundwater bodies as required by the WFD. Appropriate measures may include improved water efficiency and reducing leaks in water distribution networks. Water reuse can also be a tool for management of water quality. The CIS guidelines adopted in June 2016 provide information on integrating water reuse into water planning and management in the context of the WFD.

In 2007, the Commission communication on Water Scarcity and Droughts highlighted that at least 11% of Europe's population and 17% of its territory had been affected by water scarcity[17]. As such, water scarcity and drought are no longer issues confined to southern Europe. Despite their generally temperate climate, regions in northern European countries are also faced with seasonal water stress: freshwater sources are under pressure from the ever-increasing demands for water from growing populations and industrial use supporting their economies. At the same time climate change has put additional pressure on water resources across the EU and Member States' environmental regulators are reducing the volumes of water that can be abstracted from surface and groundwater to support, inter alia, the objectives of the Water Framework Directive. The 2007 Communication on Water Scarcity and Droughts set out a water hierarchy to guide actions to tackle water scarcity. Given the huge potential for water savings in the EU, the Communication laid down a water hierarchy under which water demand management should come first, and alternative supply options such as water reuse should only be considered once the potential for water savings and efficiency has been exhausted. It is also important to note that in some cases water reuse can help address local water quality issues.

The Blueprint for Safeguarding European Waters (the Blueprint)[18] identified water reuse as an important measure requiring EU attention and that a coordinated effort will be required at EU level to inject confidence and increase uptake of water reuse practices. This was pursued further in the 2015 Communication 'Closing the loop – An EU action plan for the Circular Economy'[19] that identified a series of actions to promote the reuse of treated wastewater. These actions were presented in December 2015 in an action plan for water reuse covering the whole value chain, and focusing on concrete measures with clear EU added value, aiming at 'closing the loop of the circular economy'. The action plan lists five initiatives, intended to be developed in the coming years, as follows:

1. Reuse in integrated water planning and management: guidelines have been developed with Member States and stakeholders to help considering water reuse more systematically when implementing EU water legislation. The guidelines contain recommendations on how to better integrate water reuse into water planning and management within the EU policy framework while taking into account underlying environmental and socio-economic benefits[20];

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[17] European Commission, COM(2007)414, Addressing the challenge of water scarcity and droughts in the European Union

[18] European Commission, COM (2012)673, Blueprint for Safeguarding European Waters" (EU Water Blueprint)

[19] European Commission, COM (2015)614, Closing the loop – An EU action plan for the Circular Economy'

[20] developed under Task 2 of this project

2. Setting minimum quality requirements for reused water for agricultural irrigation and groundwater recharge (i.e. the focus of this study is to support the Commission's impact assessment on this action);
3. Integration of water reuse provisions into the BAT reference documents (BREFs) under the Industrial Emissions Directive;
4. Support for research and innovation; and
5. Better access to EU funding for water reuse infrastructure.

It is important to emphasise that there is no 'one size fits all' solution to water scarcity and over-abstraction across the EU. As such, while this report considers EU wide options, it is important to emphasise that reuse of treated wastewater is one of the measures which can be used by individual Member States if deemed appropriate. When water reuse is deemed to be the most appropriate measure, an analysis of risks and benefits for both the environment and human health needs to be performed.

3. Problem definition and baseline development

3.1 Overview of the problem

Europe's freshwater resources are under increasing stress in several regions, with a mismatch between demand for, and availability of, water resources across both temporal and geographical (spatial) scales[21] . The concentration of population near coastlines, where the freshwater supplies are limited, has contributed to increased stress on freshwater resources. Similarly, societal changes such as population growth and diet changes have had an impact on the use of water. The JRC noted that the increase of animal and dairy products in people's diets led to an increased demand of water for agricultural production[22]. It is expected that by 2030, water stress and scarcity will affect half of the European water basins[23].

Water in Europe is used for a range of activities including agriculture, public water supply, electricity generation and industry. Agriculture is the most important category accounting for 36% of the total annual water use, followed by public water supply (32%). This varies according to seasons and the use of water for agriculture increases to 60% during the summer. The share of water use for agriculture also varies by Member State; for example in the Mediterranean region this accounts for 75% of the total water use for agriculture in Europe[24].

Findings from a 2010 survey on agricultural production methods found that more than half of the water used in agriculture is from groundwater abstraction in Austria, Denmark, Hungary, Germany, the Netherlands and Slovakia[25]. For over 40% of farms in Italy, Greece, Slovenia and Cyprus, irrigation water comes from off-farm water supply networks.

The EEA noted that water scarcity and droughts affect water basins differently in particular seasons. The Mediterranean region and most of the densely populated river basins are considered 'hot spots' for water stress conditions and are affected to some extent for the whole year. Overall water scarcity is more pronounced during the summer months (with 70 million inhabitants affected), while in winter it is estimated that 30 million people (6% of the total EU population) live under water stress conditions[26].

Eurostat provides an indicator of water scarcity, the Water Exploitation Index plus (WEI+), which compares the percentage of total freshwater used with to the total renewable freshwater resources available. A WEI+ above 20% implies that a water resource is under stress, and over 40% implies that the water resource is under severe stress. Figure 3.1 presents WEI+ for Europe's most water stressed river basins based on data from 2002-2012.

[21] EEA, 2016, Use of freshwater resources http://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/assessment-1

[22] JRC, 2014

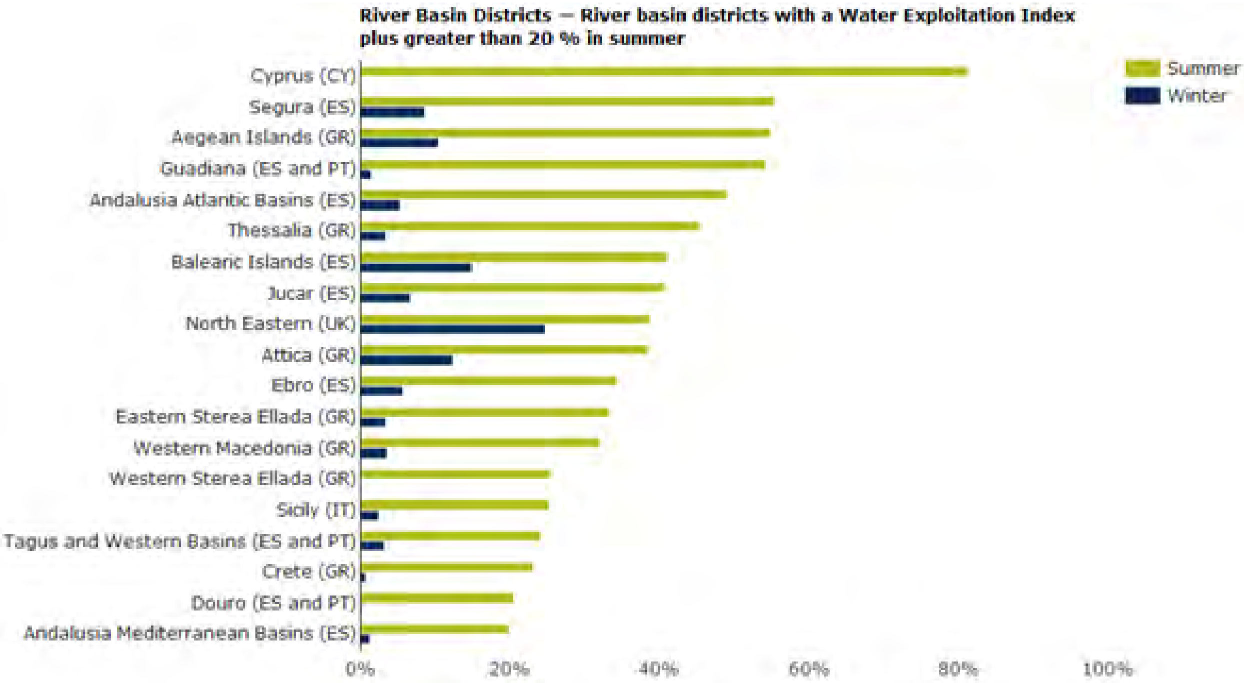
[23] European Commission, 2012, Blueprint

[24] EEA, 2016, Use of freshwater resources http://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/assessment-1

[25] Eurostat, agri environmental indicator irrigation, accessed June 2016 http://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_irrigation

[26] EEA, 2016, Use of freshwater resources http://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/assessment-1

Figure 3.1 European water stress index plus at basin level for 2002- 2012



Source: EEA, 2016

It can be observed that there are 20 river basin districts with a WEI+ above 20%; these are located primarily in the Mediterranean, including Cyprus, Malta, Greece, Italy and Spain. The situation is worse in summer for all, in particular when the demand from both agriculture and tourism is high[27].

Droughts are more common and pronounced in Southern river basis, however they are becoming increasingly important in Northern basins, including the UK and Germany[28]. Modelling conducted under the ClimaWatAdapt project estimated that the number of river basins under water scarcity was expected to increase by up to 50% by 2030[29]. Drought and scarcity manifest themselves in different ways in different countries, depending on their individual water resource infrastructure systems, economic ability to harness and access resources, and the nature of demand, but the consequences are similar: inadequate supplies of water for irrigation suppress harvests and diminish crop quality; power stations across Europe have been forced to reduce power output because of insufficient water for cooling; competition for diminished supplies has left all sectors at risk of restrictions – all of which contribute to economic underperformance. Due to droughts and water scarcity, the quantity of surface and groundwater available for agriculture is reduced (due to competing uses from public water supply and industry such as energy generation) which in turn compromises agricultural outputs and nutritional value of the agricultural production. A survey conducted in the Po region of Italy found that drought had led to a reduction of the income of farmers by on average 20-30% due to the limitation of the volume of water that each farmer was allowed to use and consequent reductions in production[30]. The European Commission estimated in 2012 that the cumulative financial burden arising from water shortages over the 1976 to 2006 period has been in the order of €100 billion and so identified the need for long term, sustainable solutions[31].

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[27] EEA, 2016, Use of freshwater resources http://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/assessment-1
[28] European Commission, SWD(2012)380, Report on the review of the European Water Scarcity and Droughts Policy http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0672&from=EN
[29] European Commission, SWD(2012)380, Report on the review of the European Water Scarcity and Droughts Policy http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0672&from=EN
[30] Verlicchi P, et al A project of reuse of reclaimed wastewater in the Po Valley, Italy: Polishing sequence and cost benefit analysis, Journal of Hydrology, 432-433 (2012) 127-136
[31] European Commission, SWD(2012)380, Report on the review of the European Water Scarcity and Droughts Policy http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0672&from=EN

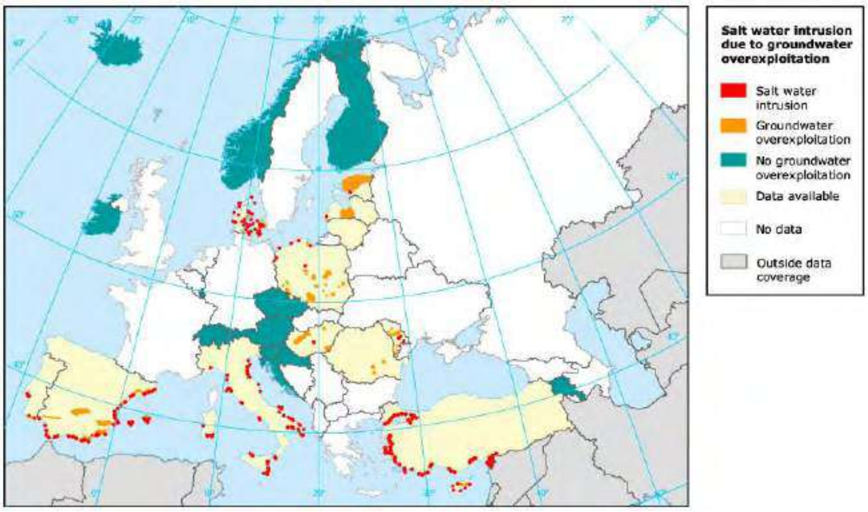
Global climate change is already exacerbating these problems with projections indicating significant and widespread impacts over the medium to long term. Growing competition for water resources between different water-using sectors is already emerging and the Blueprint identified that, due to competing demands, an estimated 40% global water shortage could be expected by 2030 (EC, 2012).

A review of freshwater abstraction by sector during the period 2000-2010 (OECD, 2015) shows that, in OECD countries, irrigation in total accounts for 63% of water use followed by water cooling for power generation (19%), public water supply (16%) and the manufacturing industry (2%). Overall around 20% of the total annual water was abstracted in 2010 from groundwater sources (6,595 million m^3) and 80%, from surface sources (26,949 million m^3). Gross water abstraction declined by 8% during the period 2000-2010, but groundwater abstraction has increased by 10% in the same period. These trends have remained mostly stable since then.

Out of the surface resources, rivers represent 46% of the water abstracted. There are seasonal variations in abstraction and the EEA notes that water abstraction increases almost twofold in summer compared to winter.

Water over-abstraction, particularly for irrigation purposes but also for industrial use and urban development, is one of the main threats to the EU water environment. Irrigation for agriculture was identified as the main source for water over abstraction in the Mediterranean basins, with urbanisation and other economic activities being sources of over-abstraction in other river basins[32]. In 2015, it was estimated that over-abstraction significantly affects 10% of surface water bodies and 20% of groundwater bodies[33].The EEA noted that the increased reliance on groundwater as a source of freshwater has led to the lowering of water tables, the depletion of wells, higher pumping costs and, in coastal areas, to saline intrusion which degrades the groundwater quality. In riverine ecosystems, over-exploitation alters the natural hydrological regime and affects the whole ecosystem.

Figure 3.2 Groundwater overexploitation and saline intrusion



Source: EEA, 2008[34]

[32] European Commission, COM(2015)120), The WFD and the FD: actions towards the 'good status' of EU water and to reduce flood risks. http://ec.europa.eu/environment/water/water-framework/pdf/4th_report/COM_2015_120_en.pdf
[33] European Commission, COM(2015)120), The WFD and the FD: actions towards the 'good status' of EU water and to reduce flood risks. http://ec.europa.eu/environment/water/water-framework/pdf/4th_report/COM_2015_120_en.pdf
[34] EEA, 2008, Impacts due to over abstraction. http://www.eea.europa.eu/themes/water/water-resources/impacts-due-to-over-abstraction

Resource availability is further compromised by **poor or unsuitable water quality,** which in addition to the environmental impact can significantly increase the financial costs of supply.

In 2015, the EEA reviewed the ecological state of freshwater in Europe (considering both quantity and quality) and concluded that while there had been an improvement, water quality remained a challenge for several river basins, with 53% of water bodies showing a good / high ecological status[35]. Many EU rivers and groundwater bodies have high levels of nutrient enrichment (including nitrogen (N) and phosphorus (P)) which result from diffuse agricultural inputs and, in part, from waste water treatment plant (WWTP) discharges (the concentration of N and P released depends upon the degree of sophistication of nutrient removal processes deployed in WWTPs)[36] . Other diffuse pollution includes pesticides. In 2015, it was estimated that diffuse pollution significantly affects 90% of river basin districts, 50% of surface water bodies and 33% of groundwater bodies across the EU[37]. The environmental impacts of water quality degradation include degradation of surface and groundwater ecosystems, degradation of soil quality, ecosystems deterioration and loss of agricultural productivity.

The fact that Europe's water resources are unevenly distributed makes it unsuitable to adopt a 'one-size fits all' approach (even sometimes within a Member State). However several regions experience at least temporary water stress conditions, characterised by an imbalance between the water demand and the available renewable freshwater resources, and solutions are needed that reflect local conditions and characteristics. In addition to the traditional sources of water, two alternative sources of freshwater are available: water reuse and seawater desalination. As described in section 2, water reuse is, after water saving and improving water efficiency, a possible option to respond to challenges with both water quality and quantity. The addition of treated waste water to waterbodies whose quality does not meet the required good status can lead to an improvement of the qualitative status. Similarly, the addition of treated waste water to waterbodies with low quantity can lead to an improvement of the quantitative status.

Furthermore, the European Innovation Partnerships on Water and on Agricultural Productivity and Sustainability have focused on finding options to meet environmental objectives while creating market opportunities. It is estimated that a 1% increase in the rate of growth of the water industry in Europe could lead to the creation of up to 20,000 jobs (JRC, 2014). Water reuse is also seen as contributing to other objectives, for example those of a resource-efficient Europe, the resource-efficient Smart Cities initiatives and other global objectives (e.g. Water Environment Research Foundation). For these reasons, water reuse has been listed as one of the priorities of the Strategic Implementation Plan of the European Innovation Partnership on Water (EIPW, 2012).

While water reuse is an accepted practice in several EU countries with severe water scarcity issues (e.g. Cyprus, Spain and Italy), where it has become an integral and effective component of water resources management , the present **uptake of treated wastewater reuse solutions** despite its potential advantages **remains limited at EU level**.

3.2 Current water reuse in Europe

In 2011, 7km^3 per year of municipal treated wastewater was reused throughout the world and this represented 0.59% of the total water use. Global Water Intelligence estimated that the market for reuse was globally on the verge of expansion and expected it to outpace desalination in the future. It is foreseen that, by 2030, water reuse will represent 1.66% (26 km^3 per year) of the total water use[38]. Globally, agricultural irrigation is the main application for water reuse with 32% of the reclaimed water used for this purpose. This is followed by landscape irrigation (20%) and industrial uses (19%). Recharge of groundwater is one of the least developed global uses with 2% of the reclaimed water being used for this purpose. However, this and indirect drinking water were highlighted as an application with important potential[39].

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[35] EEA, 2015, State of the Environment Report, Freshwater http://www.eea.europa.eu/soer-2015/europe/freshwater

[36] EEA, 2015, State of the Environment Report, Freshwater http://www.eea.europa.eu/soer-2015/europe/freshwater

[37] EEA, 2015, State of the Environment Report, Freshwater http://www.eea.europa.eu/soer-2015/europe/freshwater

[38] Global Water Intelligence, 2015, Summary of Vol I

[39] Global Water Intelligence, 2016 in Ohkuma N, 2016, the situation of the international standardisation for water reuse http://www.horiba.com/uploads/media/R43E_04_011__________01.pdf

In 2006, the total volume of reused treated wastewater in the EU amounted to 964 million m³/year, accounting for 2.4% of the treated urban wastewater (about 1 billion cubic metres) or less than 0.5% of annual EU freshwater abstraction[40]. No data were available on the current volume of treated wastewater being reused in the EU; however the previous study to support the impact assessment estimated the current volume of reused treated wastewater in the EU at 1,100 million m^3/year or 0.4% of annual EU freshwater abstractions (BIO, 2015). The collection of information has not identified another EU wide estimate however some Member State level data are presented in the table below and in Appendix D.

Table 3.1 Reuse of treated wastewater (2006)

Country	Volume, million m3 per year
EU	964
Spain	347
Italy	233
Germany	42
Greece	23

Source: TYPSA (2013)

In 2006, Spain and Italy jointly accounted for about 60% of the total EU treated wastewater reuse volume. Other countries are reusing much less, and the reuse figures broadly decline the further north one goes. In relative terms (i.e. in comparison to treated wastewater volume generated in each of the Member States), reuse was considered significant in Cyprus and Malta where 89% and about 60% of treated wastewater treatment plant effluents are being re-used respectively. In other countries, such as Greece, Italy and Spain reuse of treated wastewater constituted between 5% and 12% of total treated effluent from wastewater treatment plants.

Some countries already irrigate using predominantly treated effluent. For example, in Cyprus between 2004 and 2013, 89% of the treated wastewater was reused and a significant part of this (75.5% in 2013) was used for agricultural irrigation. As such, reusing treated effluent discharged from wastewater treatment plants to support agricultural irrigation has significant potential to reduce pressure on stressed freshwater sources that are in demand for potable use.

Examples of agricultural irrigation projects involving water reuse have been identified in several Member States, in particular:

- In Italy, at the Milano Nosedo WWTP, reuse was established in 2000[41]. The WWTP is the largest of the region, treating an approximate 150 million m^3/year of wastewater. The WWTP is located in a large agricultural region cultivating corn, rice, grass and grain. In 2014 157.4 million m^3 was treated and made available for irrigation purposes. The treated water is released in the Vettabbia stream. Farmers of the region are required to pay a concession charge of €1,827 to be allowed to abstract water from the Vettabia stream. The fee paid does not vary according to the volume of water abstracted. Furthermore the WWTP conducts nutrient recovery, in

40 No comprehensive and up to date information exists on the volumes of reused treated wastewater in different Member States. While some reporting requirements exist under the UWWTD, a series of research projects investigating how much reuse is actually happening across Europe, by whom, and for what purpose provide the main body of evidence on reuse of treated wastewater across the EU. Aside from the existing study completed by BIO (BIO, 2015; http://ec.europa.eu/environment/water/blueprint/pdf/BIO_IA%20on%20water%20reuse_Final%20Part%20I.pdf) on optimising water reuse, the most recent studies are the 'Water Reuse in the European Union' (and update) reports completed by TYPSA in 2012[40] and 2013[40]. The work draws on data collated and analysed by the AQUAREC project covering 2006-07. In addition in December 2014 the EU (JRC) released a report on 'Water Reuse in Europe, Relevant guidelines, needs for and barriers to innovation'(http://publications.EU (JRC).ec.europa.eu/repository/handle/EU (JRC)92582). At the core of much of this research were published academic papers (e.g. Hochstrat et al., 2005a; Hochstrat et al., 2005b; Bixio et al., 2006; and Bixio et al., 2008) and an estimation methodology (Hochstrat et al., 2005a), which incorporated climate change considerations and used scenario analyses to test the potential versus the actual reuse situation.

41 Presentation from Roberto Mazzini, the case of Milano-Nosedo municipal WWTP. http://ebcd.org/wp-content/uploads/2015/12/The-Case-of-Milano-Nosedo-municipal-WWTP-Roberto-Mazzini-.pdf

particular phosphorus which is not renewable and which is considered to provide additional nutrient for farmers and to reduce their needs for fertilisers. Open days to present the activities of the WWTP to the general public and to farmers are organised in order to encourage acceptance;

- In Ferrandina, Southern Italy, municipal waste water is treated to retain nitrogen. This has led to reductions in cost of treatment due to the disposal of biological sludge as an end-product of standard treatment processes. The treated water is transported to an olive orchard using a dedicated pipeline and is supplied by drip irrigation[42];
- Since 2014 a private company in the Netherlands has operated the AquaReUse water treatment facility[43] which collects wastewater from ten horticulture companies and treats it for the purpose of reusing it as irrigation water, meeting the relevant quality requirements of the horticulture farmers. The installation uses an artificial wetland, filters and reversed osmosis before using the treated water for irrigation and aquifer storage-recharge. On average, the facility provides 123,000m3 of water to the greenhouses. Surpluses are injected into the ground to be used as a reserve[44]; and
- In France, a local reuse project has been deployed in the vicinity of Clermont Ferrand. The aim is to reuse the treated effluents from a sugar refinery factory in order to irrigate the 1,400ha farmed in the near proximity. The impossibility of extracting further water from the local canal was limiting agricultural production and, out of the 1,400 ha, only 200 ha could be irrigated. During the winter, the effluent from the sugar refinery is spread on agricultural land in order to provide nutrients and organic content and in the summer the effluent is used to irrigate crops. In between these two seasons, water is stored within a lagoon. A cost benefit analysis of this scheme found that overall it was beneficial for the industry and farmers but also for the local authorities[45].

Reused treated wastewater can also be used for environmental purposes such as **recharging aquifers** in order to protect groundwater from saline intrusion or to store reclaimed water in the winter months as a buffer stock, in order to better address the demand during the summer. Given that aquifer recharge has many advantages (negligible evaporation, little secondary contamination by animals, no algal blooming and in some instances no need for pipeline construction), it is an interesting alternative to conventional surface water storage (BIO, 2015). However, it also bears environmental risks that should be considered. Treatment requirements should therefore be appropriately strict to ensure non-deterioration of water bodies.

There are examples of artificial aquifer recharge projects being set up in Member States including:

- A recharge scheme for the Ezousas aquifer in Cyprus, where treated water is mixed with water from the Asprokremmos dam before being recharged in the aquifer through specially constructed shallow ponds. This water, after natural purification, is pumped from the aquifer for irrigation. Pumping is carried out strategically so that retention time in the aquifer is maximised; and
- While there is no legislation in Belgium on water reuse for aquifer recharge, the Torreele water plant has reused municipal treated water to produce infiltration water for groundwater recharge. The aquifer is used to abstract potable water so specific standards were set including technological requirements for ultrafiltration and reverse osmosis[46].

[42] Dichio B., Palese AM, Montanaro G., Xylogiannis E., Sofo A., 2014. A Preliminary Assessment of Water Footprint Components in a Mediterranean Olive Grove. Acta Horticulturae, 1038: 671-676

[43] http://www.pb-techniek.nl/en/nieuws/aquareuse-officially-opened

[44] Presentation from Theo Cuijpers Dutch Regional Water Authority, http://ebcd.org/wp-content/uploads/2015/12/AquaReUse-Reusing-water-for-irrigation-in-greenhouses-Theo-Cuijpers.pdf

[45] ONEMA and irstea, Partneariat 2013-2015, Analyses couts-benefices sur la mise en oeuvre de projects de reutilisation des eaux uses traitees (REUSE).

[46] DOW, Water & Process Solutions, Indirect Potable Reuse via Groundwater Recharge in Belgium, http://msdssearch.dow.com/PublishedLiteratureDOWCOM/dh_053c/0901b8038053c343.pdf?filepath=liquidseps/pdfs/noreg/609-02150.pdf&fromPage=GetDoc

Out of the Member States where water reuse is being practiced, standards have been developed by Cyprus, France, Greece, Italy, Portugal and Spain. In all countries apart from Portugal these standards are legally binding. In the global reuse market, a move toward standardisation has been observed in recent years[47]. The WHO and ISO have published guidelines on safe use of wastewater including for irrigation use. Water reuse is an **emerging worldwide market** and a greater uptake of reuse at the EU level would provide a showcase for the relevance of these technologies and skills of EU companies towards potential customers in third countries.

Many of the standards developed at Member State level have been informed by the WHO Guidelines, the ISO standards and other countries' approaches (e.g. Australia, Israel and the USA) but also by national specific considerations[48]. As a result there is no homogeneity between the standards in individual EU Member States (JRC, 2014).

A recent OECD report on Water and Cities indicated that water reuse requires specific regulations on the quality of reclaimed water.[49] However the report does not specify its justifications for doing so although it highlights the need for a clear legal definition of wastewater as a resource to promote water reuse.[50]

Global Water Intelligence has identified signs that large companies are more than ever ready to invest in water solutions and in that context water reuse technologies are being seen as the way to unlock a potential for growth but also as a way to provide a secure water source for economic activities[51]. Technology providers in this sector are EU-scale companies and differences in standards among Member States can prevent companies benefitting from a clear framework allowing economies of scale. EU-wide action would provide further incentives to **encourage investments in innovation and technologies** for reuse in the water industry.

3.3 Key barriers to reuse of treated wastewater in Europe

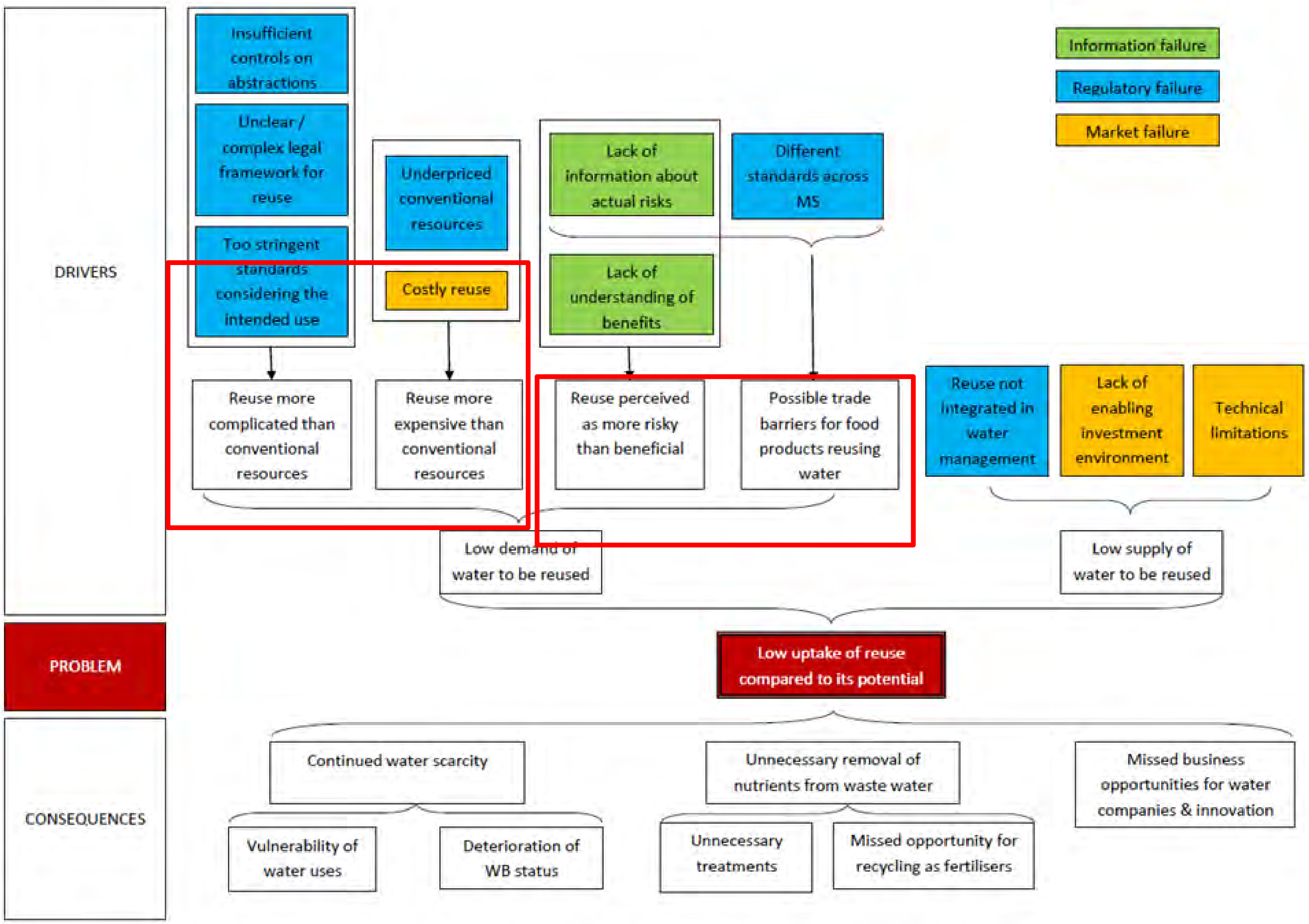
The previous study to support the Commission's impact assessment estimated that the reuse potential that might be achieved in the case of stronger regulatory and financial incentives at the EU level are of the order of 6,000 million m^3/year by 2025. This estimate builds on the AQUAREC model and assumes that five of the Member States with the highest reuse potential (Italy, Germany, France, Portugal and Greece) could reach the same water reuse rate as Spain by 2025, expressed as a percentage of their total annual water abstraction, i.e. 4% of their total annual water abstraction. **Despite the reuse of treated wastewater being an accepted practice in several EU Member States experiencing water scarcity issues**, including Spain, Italy, Cyprus, France, Greece, Malta and Portugal, **only a small proportion of treated wastewater is currently reused in the EU**. Most of the reuse conducted is for irrigation purposes.

Key barriers that are inhibiting more mainstream uptake of reuse as a source of non-potable water, and associated environmental, social, and economic consequences are presented in Figure 3.3. The barriers further elaborated in this report are those addressed by the EU proposal, with other barriers addressed by actions implemented as part of the action plan on Circular Economy (see Section 2.2).

As a result of these barriers and whilst the potential for reuse is no longer in question, based on local considerations, it remains peripheral rather than mainstream in the toolbox used by many water resource managers and without concerted policy effort this situation is unlikely to change.

[47] Ohkuma N, 2016, the situation of the international standardisation for water reuse http://www.horiba.com/uploads/media/R43E_04_011__________01.pdf
[48] EUWI MED (2007) Mediterranean Wastewater Reuse Report produced by the Mediterranean Wastewater Reuse Working Group (MED WWR WG)
[49] OECD, 2015, Water and Cities, Ensuring Sustainable Futures
[50] OECD, 2015, Water Resources Allocation, Sharing risk and opportunities
[51] Global Water Intelligence, 2015, Vol I summary

Figure 3.3 Problem tree for water reuse initiatives



Source: European Commission

The key barriers and challenges identified can be grouped into the following categories:

- Water reuse is more complicated than conventional resources;
- Water reuse is more expensive than conventional resources;
- Water reuse is perceived as being more risky than beneficial; and
- Possible trade barriers for food products grown using reused water.

Water reuse is more complicated than conventional resources

While the **technical difficulties** to implement a water reuse infrastructure are real and water reuse may be more complicated than direct abstraction, the feedback from the public consultation found that technical difficulties were one of the least frequently mentioned sources of barriers. Conversely, the water reuse sector in the EU is described as mature and technical solutions are available and well known[52].

One of the most difficult aspects of planning and designing a reuse scheme was identified as the need to pitch the level of treatment and the choice of treatment technology appropriately. There is a lack of clarity and uncertainty over both the levels of treatment required to produce water that meets (as yet undefined) 'appropriate' water quality standards, and the risk of 'over-engineering' water treatments resulting in excessive energy and carbon footprints, at odds with European carbon emissions policy. Scheme design needs to take into account the quality of the influent wastewater and the quality requirements of the purpose of use. Design and implementation of an under-performing treatment system could lead to unacceptable or unreliable water for reuse (defeating the object of improved resilience and water security).

In addition, the **distribution of wastewater and its storage** represents a barrier. Typically the points of use will not be located within the immediate proximity of a wastewater treatment works providing the treated water. Furthermore, there is a temporal mismatch between the production of the treated water (continuous) and the need for treated water.

There are two options in this case. The first option is that the treated effluent can be discharged into receiving waters for subsequent re-abstraction (constituting planned indirect reuse for which the hydrological implications of this type of flow influence will need to be considered). This also generates risk arising from lack of guarantees that the water can definitely be re-abstracted. Individual Member States' licensing systems may need to adjust to respond to such situations. The second option is to store the treated effluent directly until such time as it is needed. This presents additional risks as storage conditions will have to guarantee health and environment safety, and ensure that quality does not degrade over the storage period.

Water reuse is more expensive than conventional resources

From the review of the baseline in several Member States presented in Section 3.2 it can be observed that water reuse is often more costly than natural water resources. It is considered that the difference reflects the treatment costs and infrastructure needs for treated water, but it also reflects two further issues:

- The overall failure to implement water pricing provisions as required in the WFD which limits the potential to recover some of the costs generated by the treatment; and
- For agriculture in particular, the fact that irrigation water is mostly abstracted for a low price and in some instances illegally (or without a permit).

When compared to abstraction, the costs incurred through water reuse are indeed higher, including the building or upgrade of wastewater treatment plants (WWTPs) to produce water at the required standard but also infrastructure for distribution of the water. Treated wastewater is not distributed through the freshwater networks and is either transported to its reuse location or requires a parallel distribution network which represents a substantial cost[53]. However water reuse can also be compared against current options to address quantitative issues, such as desalination and water transport which also include important costs.

[52] BIO, 2015, Public consultation report on optimising water reuse
[53] Global Water Market, 2015, Vol I summary

The results of the public consultation conducted in 2014 found that on average 40% of respondents indicated that the high cost of reused water was a key barrier. This proportion increased to 50% when considering only SMEs. This view is also present in academic literature where the cost of treated wastewater is identified as the main barrier to increased uptake according to water utilities and irrigators' associations. In some places, reuse is conditioned by the market price and affected by high investment requirements due to the need for specific treatments in order to meet the required quality standards and the need for dedicated separated supply networks to deliver treated wastewater to users (Custodio, 2015).

The economic viability of water reuse schemes varies based on local conditions. A 2010 FAO study considered the economics of water reuse schemes and identified the following elements as key: justification, cost effectiveness and feasibility[54]. The first (justification) is established by the local actors, considering that the project is 'worth doing' taking into account the whole water cycle and aiming to optimise the use of water for the needs. The justification of water reuse for irrigation or aquifer recharge would be that treated wastewater is then available for use by farmers (for irrigation) or release into the natural environment (for aquifer recharge). The cost-effectiveness looks at whether the objectives can be achieved at the minimum costs. This is done by comparing water reuse schemes with alternatives. The results of this assessment will depend strongly on local considerations. The FAO recommends that cost-benefit analysis should be completed for water reuse schemes, as the basis of the feasibility assessment[55].

The costs of water reuse treatments are not proportional to the level of quality obtained (MAGRAMA, 2016) and examples of costs in Spain in order to meet the required quality standards defined in the legislation are presented in Table 3.2. The upfront investment cost can vary from 5 €/m^3 produced/day (filtration) to 736 €/m^3 produced/day (chemical treatment with a lamella settling system, ultrafiltration, reverse osmosis) and operational and maintenance costs may vary from 0.04 €/m^3 (filtration, and disinfection or depth filtration) to 0.35-0.45 €/m^3 produced/day (with lamella/double depth chemical precipitation, ultrafiltration, RO/EDR desalination and disinfection).

Table 3.2 Water reuse treatments costs in Spain

Type of treatment line	Investment cost (€/m^3/day)	Operational cost (€/m^3)
TYPE 1 (CP+F+UF+D)	185–398	0.14–0.20
TYPE 2 (CP+F+UV+D)	28–48	0.06– 0.09
TYPE 3 (F+UV+D)	9–22	0.04 –0.07
TYPE 4 (F)	5–11	0,04 –0.07
TYPE 5.a (CP+F+UF+RO+D)	416–736	0.35 –0.45
TYPE 5.b (CP+DF+EDR+ UV+D)	310–506	0.35 –0.45

*** Source:** MAGRAMA (2016) updating investing costs set up in Iglesias (2013)

* **Notes**:

[0] Treatment technologies to be applied according to water uses set up in Royal Decree 1620/2007 on reclaimed water use. Treatment lines 1 to 4 do not include desalination. Treatment line 5 includes desalination.

[1] Treatment Line 1 (quality A): Chemical precipitation (with lamella settling system, filtration with membranes (ultrafiltration) and Disinfection (residual chlorine may be needed in distribution system).

[2] Treatment Line 2 (quality B): Chemical precipitation, depth filtration and disinfection (UV+chlorination, residual chlorine may be needed in distribution system).

[3] Treatment Line 3 (quality C and D): filtration and disinfection (tendency to UV and residual chlorine).

[4] Treatment Line 4 (quality C and E): filtration but surface or depth filtration for distribution system management

54 FAO, 2010, the wealth of waste, the economics of wastewater use in agriculture

55 FAO, 2010, the wealth of waste, the economics of wastewater use in agriculture

The public consultation feedback indicated that financial incentives may be needed to encourage the uptake of water reuse. This view was supplemented by additional evidence identifying that a pricing strategy to incentivise the use of treated wastewater was possible. For example reused water tariffs in Cyprus range from 33%-40% of freshwater rates; these ratios appear typical for the EU Mediterranean islands[56]. Cyprus identified the subsidies as a strong incentive to improve acceptability of water reuse. The table below presents a comparison of the selling rates of abstracted freshwater and treated wastewater.

Table 3.3 Selling rates of the treated effluent in Cyprus

Use	Tertiary Treated Effluent	Fresh not filtered water from government water works
	€/m3	€/m3
For Irrigation divisions for agricultural production	0.05	0.15
For Persons for agricultural production	0.07	0.17
For irrigation of hotels green areas and gardens	0.15	0.34
For pumping from an aquifer recharged by the treated effluent	0.08	n.a

Source: WDD, 2008 costs

The 2010 FAO study[57] concluded that the economic appraisal of water reuse should be performed at a regional basin level. The FAO considered case studies of water reuse for agriculture and noted that in most cases net benefits for farmers were unlikely to offset the full costs of a water reuse scheme. It also highlights that the net impact of the project on the local and downstream environment would be site-specific, both in terms of benefits and costs.

Water reuse is perceived as being more risky than beneficial

The FAO noted that the risks (actual and perceived) to public health and the environment presented by water reuse are a serious obstacle to the greater uptake of the practice and that this trend can be observed worldwide[58].

Concerns over the human (and animal) health risks associated with reusing treated wastewater (e.g. via direction ingestion, dermal, or inhalation of contaminants within the water, or ingestion of bacteria or other hazards within food crops, or within fodder-fed animals) are very important. In particular, one of the most common concerns relates to the actual and perceived risks to human health from eating / being in contact with food irrigated with water reuse particularly from exposure to pathogens (e.g. *Salmonella*, *Escherichia coli*, listeria, *Shigella*), viruses (e.g. hepatitis A, noroviruses) parasites (e.g. *Cryptosporiduim, Cyclospora*) potentially toxic contaminants, and persistent organic contaminants (e.g. PCBs, PAHs).

Health protection measures are indeed needed to reduce health risks to consumers, workers and local communities. These measures include for example treatment of the wastewater for irrigation; restriction of crops that can be irrigated according to the quality of the water; specification of water application techniques that minimise contamination (e.g. drip irrigation); withholding periods to allow pathogen die-off in between applications; and hygienic practices during food collection and preparation (including washing, disinfection and cooking)[59].

Other protection measures, including the management and planning of water reuse schemes are detailed in existing documents for example:

- The Common Implementation Strategy Guidelines on Integrating Water Reuse into Water Planning and Management in the context of the WFD;

[56] Hidalgo & Irusta, 2005
[57] FAO, 2010, The wealth of waste, the economics of wastewater use in agriculture
[58] FAO, 2010, Ibid
[59] FAO, 2010, Ibid

- The FAO and WHO ‘Code of Hygienic Practice for Fresh Fruits and Vegetables’;
- The US EPA guidelines on water reuse;
- The WHO guidelines on safe use of wastewater; and
- ISO guidelines for treated wastewater use for irrigation projects Parts 1, 2 and 3.

In addition to health concerns, environmental risks must be considered. For example, chemical contaminants from inorganic salts, nutrients, heavy metals and detergents can negatively affect the environment. For heavy metals there are concerns that these substances can build-up in the soil aver time. Salinity of the water is also a risk to the environment and crops (in case of irrigation).

Where the treated water contains nutrients, using it for irrigation can be an environmental benefit whereby the nutrients are used by the crop rather than discharged into water bodies, thus reducing risks of eutrophication. However, nutrient uptake depends on the stage of growth of the crop, and this can be difficult in practice. This leads to the risk of nutrient run-off and increased eutrophication. There are also growing concerns over the fate of the wide variety of emerging contaminants (e.g. pharmaceuticals, contaminants of emerging concern (CECs)), which are present in sewage, often at trace levels, and often unmonitored. Evidence remains limited as to how well treatment processes deal with these pollutants.

While it is important to acknowledge health and environmental risks, most of these risks can be addressed by applying suitable barriers, the most important barrier being treatment of wastewater. There are several techniques available that allow different level of water quality to be reached. The dual membrane tertiary treatment process that combines micro-filtration and reverse osmosis, allows the highest quality of treated water to be achieved. However it is also costly so there may be benefits in adapting the treatment levels to the intended use. This approach has been adopted in the Member States’ national legislation that define water quality level per category of use. The use of advanced treatment technologies in order to produce water reuse fit for purpose can be costly but it also represents an economic market. Global Water Intelligence estimated that the global reuse market in 2016 exceeded €7,200 million (US$8,000 million), which is almost double the level of 2010[60].

Closely linked to the issues of risks (or perceived risks) is the issue of acceptance. It is likely that standards demonstrating that the removal of viruses, protozoa and bacteria is monitored and controlled will be required in order to persuade stakeholders that agricultural products grown using treated wastewater pose no threat to health. Furthermore evidence from existing reuse schemes around the world indicates that action to proactively tackle perception issues can be valuable to increase acceptance[61].

The risk perception is compounded by a generally low level of awareness of the benefits of water reuse. Beyond the availability of water and the mitigation of water scarcity, potential benefits such as energy savings , reduced environmental impacts from reduced fertilisers use (where possible) and local economic development are not widely recognised.

The DEMOWARE FP7 project has a specific objective to promote a wider understanding and awareness of water reuse practices among public administrations and end-users (objective 6). It recently organised a citizen focus group in Spain hosted by a water company. It found that, in general, the level of awareness of citizens in the region is high and they have a positive attitude towards water reuse. However, despite this, health and safety concerns were voiced during the meeting and it was recommended to have more transparency and more involvement from health authorities (e.g. ministries or agencies for health) to provide reassurance with regard to the safety of the reuse practices. Furthermore, one of the DEMOWARE deliverables, ‘Trust in Reuse’, summarises the strategies to improve trust in water reuse in order to improve public support[62]. Another means identified as successful in raising trust in water reuse is to present its role in the wider water cycle and explain all procedures and treatments that can make water reuse safe for human health and for the environment.

[60] Global Water Intelligence, 2016 in Ohkuma N, 2016, the situation of the international standardisation for water reuse http://www.horiba.com/uploads/media/R43E_04_011__________01.pdf
[61] BIO, 2015 for further evidence
[62] DEMOWARE, 2015, Trust in Reuse, Deliverable 5.2 http://demoware.eu/en/results/deliverables/deliverable-d5-2-trust-in-reuse.pdf

Possible trade barriers for food products grown using reused water reuse

Member States apply different standards when opting for water reuse which can be a barrier for agricultural goods to access the single market. The case of the *e.coli* outbreak in 2011, killing 16 people in spring 2011 is an example of this situation. The outbreak was blamed on cucumbers irrigated with treated wastewater and imported from Spain and several Member States, including Germany, Denmark, the Czech Republic and Belgium blocked or restricted the import of Spanish products over concerns that these would have been contaminated during irrigation. It was subsequently proven that the source of the *e.coli* contamination was not the cucumbers but rather sprouted germs from a German farm. It was estimated that this event cost Spain €200 million per week as orders were cancelled[63]. This example shows that the threat of trade restriction on agricultural products is real, and that a common understanding on what is considered to be safe practice for water reuse in irrigation could be beneficial to prevent this situation happening.

The total value of agricultural production in the EU28 countries was €421.8 billion in 2013 of which crop output represented 50.6%[64]. An approximate estimate of the value of irrigated crops is €13 billion[65]. The EU is one of the biggest producers of cereal and is an important trader of cereal. It exported 32 million tonnes of cereal outside the EU and traded 263.8 million tonnes within the EU itself, predominately in wheat[66]. As such the threat of trade barriers for irrigated agricultural goods is important.

In 2013, the total irrigable area in the EU was 18.7 million ha with 10.2 million ha actually irrigated. The spread of irrigation varies by Member State, with southern countries having the largest irrigable and irrigated areas[67]. In central and western Europe, irrigation is used on a supplementary basis, to improve crop production during dry summers and is characterised by relatively large irrigable areas but smaller areas actually being irrigated. The table below presents the difference between irrigable and irrigated areas in each Member State in 2013.

Table 3.4 Overview of irrigable and irrigated areas in Member States in 2013

Member State	Total irrigable area (in ha)	Total irrigated at least once a year (in ha)	Percentage of irrigated area
Belgium	19,180	5,740	30%
Bulgaria	115,520	98,670	85%
Czech Republic	34,070	17,840	52%
Denmark	438,980	241,980	55%
Germany	691,260	365,590	53%
Estonia	430	310	72%
Ireland	0	0	0%
Greece	1,516,930	1,164,620	77%
Spain	6,751,710	2,898,970	43%
France	2,811,440	1,423,640	51%
Croatia	25,870	13,430	52%

63 The Telegraph, http://www.telegraph.co.uk/news/health/news/8548311/Cucumber-E.coli-scare-UK-shops-reassure-consumers-as-Spain-demands-compensation.html

64 Eurostat, 2014, Agricultural accounts and prices http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_accounts_and_prices

65 Author's calculation, assuming 6.2% crops on average are irrigated at EU -28 level in 2013 and value of crops production in 2013

66 European commission (2012) Agriculture in the European Union, Statistical and economic information, 2011.

67 Eurostat, 2013, Agri-environmental indicator: irrigation. http://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_irrigation

Member State	Total irrigable area (in ha)	Total irrigated at least once a year (in ha)	Percentage of irrigated area
Italy	4,004,450	2,866,330	72%
Cyprus	38,060	24,670	65%
Latvia	630	410	65%
Lithuania	4,080	1,600	39%
Luxembourg	No data	No data	-
Hungary	258,960	141,190	55%
Malta	4,200	3,660	87%
Netherlands	499,400	101,770	20%
Austria	119,840	51,680	43%
Poland	75,810	45,550	60%
Portugal	551,760	477,160	86%
Romania	230,390	152,840	66%
Slovenia	4,270	2,540	59%
Slovakia	99,640	24,600	25%
Finland	102,130	9,510	9%
Sweden	155,520	51,870	33%
United Kingdom	115,380	49,130	43%

Source: Eurostat, 2013, Irrigation: number of farms, areas and equipment by size of irrigated area and NUTS 2 regions [ef_poirrig]

Standards adopted by Member States for water reuse specify intended uses which are mostly agricultural and urban applications. The Spanish and the Greek standards are those for which the highest number of uses is included. In comparison the Portuguese guidelines only refer to use for irrigation of urban areas and agriculture. All the standards cover the reuse water for the agricultural irrigation of crops and orchards and all but Cyprus's cover water reuse for irrigation of pastures. Aquifer recharge (by percolation or direct injection) is only included as a permitted use in Cyprus, Greece and Spain.

The 2014 review by the JRC of the existing legislation[68] identified examples of variations in the standards being set. The differences are presented in Table 3.5.

[68] JRC, 2014

Table 3.5 Differences in maximum limit values for selected parameters considered in national standards for water reuse

Parameters	Cyprus	France	Greece	Italy	Portugal	Spain
E coli (cfu/100ml)	$5\text{-}10^3$	$250\text{-}10^5$	5-200	10	-	0-10,000[69]
Faecal coliforms	-	-	-	-	$100\text{-}10^4$	-
TSS	10-30	15	2-35	10	60	5-35
Turbidity (NTU)	-	-	2-no limit	-	-	1-15
Biochemical oxygen demand (BOD 5) (mg/l)	10-70	-	10-25	20	-	-
Chemical oxygen demand (COD) (mg-l)	70	60	-	100	-	-
Total nitrogen (mg/l)	15	-	30	15	-	10

Source: Reproduced from JRC, 2014. '-' indicates that there is no value set for the parameter in the national legislation

Specific barriers to water reuse in irrigation

In the context of specific barriers to treated wastewater reuse in irrigation, the public consultation identified that, for the agricultural sector, the fact that water reuse was not considered as a component of integrated water management and the fear of trade barriers for agricultural goods irrigated with reused water (62% of respondents) were the most important obstacles. Irrigation of crops to be eaten raw with reused water was found to be the least-supported use. Furthermore, 50% of the agricultural sector respondents considered that the stringency and variation of the national standards constituted a serious barrier.

Differences of requirements between Member States can lead to inequalities for agricultural producers entering the single market with goods irrigated by reclaimed water treated to different standards in different Member States. While no evidence was identified in the EU, in California, there are considerations about requesting mandatory labelling for food products irrigated with treated wastewater from hydraulic fracturing activities[70]. While the type of water considered is different (wastewater from oil and gas activities rather than urban), there are similarities in the reasons to request the labelling, which is concern over human health safety implications. By analogy it is possible that Member States could introduce similar labelling requirements which could lead to the discrimination of these products. Furthermore, the lack of agreed standards triggers uncertainties on environmental and health safety in particular for consumers. Concerns were expressed about the likely effect that national regulation of treated wastewater reuse may have on prices (increase) of this type of resource (MARM, 2010). This was reinforced by the public consultation where almost 80% of the respondents indicated that the lack of clarity on regulations was a moderately to highly important barrier (with 50% viewing it as highly important). Furthermore 75% of the respondents expressed concerns over the potential trade barriers for food products that these can lead to. It is important to note that, more than the variation in stringency of the national standards, it is the absence of a unified approach that was identified by stakeholders as being the most important barrier to the increase of water reuse[71].

The risks to health and the environment from pollutants such as bacteria, viruses and emerging pollutants and priority substances such as those already detected occasionally in discharges from water treatment

[69] Note that this represents the range of different limits for different uses. For E. coli, as indicated in RD 1620/2007, the limits are 0 for more stringent values, and 10.000 for less stringent

[70] California legislature, Assembly Bill, 17 August 2015, http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520162AB14

[71] BIO, 2015, Public consultation report on optimising water reuse

plants (and in high concentrations) are also perceived as an obstacle (Estévez et al., 2016; Estévez et al., 2012).

The review of additional information identified that, in some Member States there is reluctance from farmers, rooted in the potential negative attitudes of consumers towards their products (acceptance) and concerns on how this could affect labelling requirements for accessing European markets. However no labelling requirement related to type of water used for irrigation was identified. A more positive perception of goods being irrigated with treated wastewater could be promoted through further public engagement and increasing knowledge.

On health risks, several studies have reviewed and compared levels of bacteria (e.g. E.coli) in products irrigated with treated wastewater and conventional irrigation water. A 2013 study[72] found that tomatoes irrigated with wastewater treated with membrane bio reactor technology and gravel filters were free from E.coli and found low levels of E.coli in the soil even though the concentrations in the irrigation water were high. Helminth eggs were found on two tomatoes, one of which had been irrigated with tap water and another irrigated with water treated by gravel. The authors note that wildlife could have been the source of this contamination. Following the quantitative microbial risk assessment model from the WHO, it was deemed that the consumption of the tomatoes was safe.

Another health risk study was carried out to compare the faecal contamination of soil and tomatoes irrigated by sprinkler and surface and subsurface drip irrigation with domestic water treated by Membrane Bio Reactor (MBR) technology, gravel filtration or UV-treatment at sites in Crete and Italy. The aim was to understand whether one way of irrigation was safer than another. The study notes that contamination of crops with pathogens can occur when 'overhead irrigation methods such as sprinkler irrigation is used because the edible parts are directly exposed to the applied water. Surface drip irrigation applies water at the soil surface and is less likely to contaminate high growing crops while subsurface drip irrigation applies the water direct to the roots with minimal transfer of pathogens to the crop surface'. Although this study found elevated levels of E.coli in irrigation and low concentrations of E.coli in soil, only two of 84 tomato samples in Crete contained E.coli and tomatoes from Italy were free of E. coli. The two samples of E.coli were analysed further and did not present genetic similarities leading the authors to conclude that the presence of E. coli would have been from an environmental source (i.e. wildlife). From these results it was considered that there was a weak association between E.coli found in water used for irrigation and E. coli found in irrigated soil and no association with E.coli on the tomatoes. The study also concluded that, based on the two year experiments in Italy and Crete, it is impossible to state whether subsurface drip irrigation is safer than surface irrigation as almost all tomato samples were free of E.coli.

Finally, the potential to reuse nutrients contained in treated wastewater is quoted as both a benefit and a barrier. On the one hand, use of artificial fertilisers constitutes a cost and it was estimated that the EU fertiliser market (price paid by farmers) was €17 billion in 2010 (and up to €21.4 billion in 2015) (European Commission, 2012)[73]. It is recognised that reused water could provide an alternative source of nutrients (nitrogen and phosphorus) that could be utilised by crops, leading to cost savings for the farmers. However, depending on the level of treatment, the availability of nutrients would be reduced. For example tertiary treatment, which may be needed to reach a specific water quality standard, will lead to removal of nutrients. Furthermore there are agronomic limitations in the use of nutrients contained in the treated water; crops have varying demand for fertiliser through growth seasons. Over-application of nutrients would be damaging for crops, but also the environment as it can run-off to surface water and cause eutrophication. As such the actual potential for nutrients substitution would vary according to the crops, the water content of nutrients but also the season. The DEMOWARE project[74] described two case studies where the amount of substituted mineral nitrogen fertiliser from water reuse increased by more than 100%. This was compared to considering water and nutrient management separately which led to reduction of the total nitrogen input from WWTP on

[72] Forslund A, Battilani A, Ensink J H J, Dalsgaard A, Faecal contamination and health aspects of processing tomoatoes irrigated with waste water treated by decentralised wastewater treatment technologies

[73] European Commission (2012) Study on options to fully harmonise the EU legislation on fertilising materials including technical feasibility, environmental, economic and social impacts, contract number 30-CE-0392420/00-18. Annexes to the Final report.

[74] DEMOWARE, Deliverable D1.2, Report on opportunities for nutrient reduction and recycling in water reuse schemes, 2014. http://demoware.eu/en/results/deliverables/deliverable-d1-2-report-on-opportunities-for-nutrient-reduction-and-recycling-in-water-reuse-schemes.pdf

arable land by 50%. However, the case studies note the difficulties in assessing fertilisers needs accurately and concluded that managing fertilisers input according to the fertigation concept[75] within existing reuse and recycling schemes could lead to better efficiency in nitrogen recycling. This does require, however, precise application of nutrient doses and hence a close cooperation between farmers and operators of the reuse system.

However, it is important to note that irrigation water from surface or groundwater may also contain emerging contaminants, so some perspective is needed on this issue. The issue of micro-pollutants and contaminants of emerging concern is currently being investigated by the EU groundwater expert group[76].

Specific barriers to water reuse in aquifer recharge

In the context of aquifer recharge, lack of scientific and technical knowledge (including lack of clarity of ownership and liability), coupled with low perception of this kind of technique being an important water management instrument, contribute to the low uptake at present (Escalante, 2014). However, it is worth noting that, in the public consultation, aquifer recharge was one of the most often mentioned additional appropriate uses, in particular in order to prevent saline intrusion.

The barriers identified for aquifer recharge specifically include: the limited knowledge on the receiving waters, in particular the impacts on water quality due to the mixing; technical problems associated with the design and choice of the recharge technique; poor quality of water used for the recharge (often of lesser quality than potable water or with presence of emerging pollutants -pharmaceuticals, industrial chemicals, pesticides and degradation products) resulting in a potential to degrade the receiving groundwater; downstream impacts on environment and other users; and socio-economic challenges (Escalante, 2014). The risks to health and the environment from pollutants such as bacteria, viruses and emerging pollutants and priority substances such as those already detected occasionally in discharges from water treatment plants (and in high concentrations) are also perceived as an obstacle (Estévez et al., 2016; Estévez et al., 2012).

3.4 Stakeholders affected

The limited uptake of water reuse affects in particular:

- The **environment**, because of overexploitation of water resources, and missed recycling opportunities (BIO, 2015), but also due to potential environmental risks arising from reuse of water that may not be addressed adequately;
- **Economic sectors** that are highly dependent on water supply, in terms of availability and quality, such as agriculture, the food industry, the power generation industry (e.g. for cooling processes and hydropower), tourism and the recreational industry (e.g. golf courses) (BIO, 2015);
- The **EU water industry**, which is affected through foregone business opportunities in the area of treated wastewater reuse;
- **Public authorities**, through the cost of water supply, wastewater treatment and implementation of the ‘programmes of measures’ under the WFD. In particular, not taking advantage of water reuse opportunities represents missed cost saving opportunities, e.g. by reducing drinking water supply production needs and associated costs, by limiting the need to install expensive nutrient removal processes in urban WWTPs in cases where such nutrients can be recycled through agricultural irrigation or by reducing expenses associated with the implementation of ‘programmes of measures’ (water reuse may significantly contribute to meeting environmental objectives, see section 2.1); and

[75] Fertigation is the management of fertilisers and fertilisation process using irrigation systems
[76] July 2016, JRC working group meeting

- **Society** at large, which cannot fully take advantage of the wide range of environmental, economic and social benefits associated with safe water reuse.

3.5 Future trends without EU intervention

At present, only about 1,100 million m^3/year of treated wastewater is estimated to be reused in the EU, while the EU potential for water reuse is considered to be much larger: a volume in the order of **6,000** million m^3/year **by 2025** might be achievable in the case of stronger regulatory and financial incentives at the EU level. Under the baseline scenario (i.e. a scenario where there is no further EU intervention to promote treated wastewater reuse) no significant increase in water reuse is expected to occur beyond a volume of 1,700 million m^3.

All information sources reviewed agree on the **significant potential** for further development of water reuse projects and increasing the volume of reused treated wastewater across the EU. There is no available estimate of the potential, however in 2006, the AQUAREC project developed a model[77] to estimate projections for water reuse in the EU by 2025.The projections for 2025 were presented in scenario II of the model which predicted a treated wastewater reuse volume of 3,222 million m^3/year in Europe by 2025. Spain showed the greatest reuse potential (over 1,200 million m^3/year), while Italy and Bulgaria were both estimated to have a reuse potential of approximately 500 million m^3/year. Germany and France were projected to reuse 144 and 112 million m^3/year of water respectively, followed by Portugal and Greece, which account for a reuse potential of less than 100 million m^3/year (see Figure 3.6) (JRC, 2014). France, Germany and the UK are all part of the global top municipal water treatment markets and wastewater treatment markets[78].

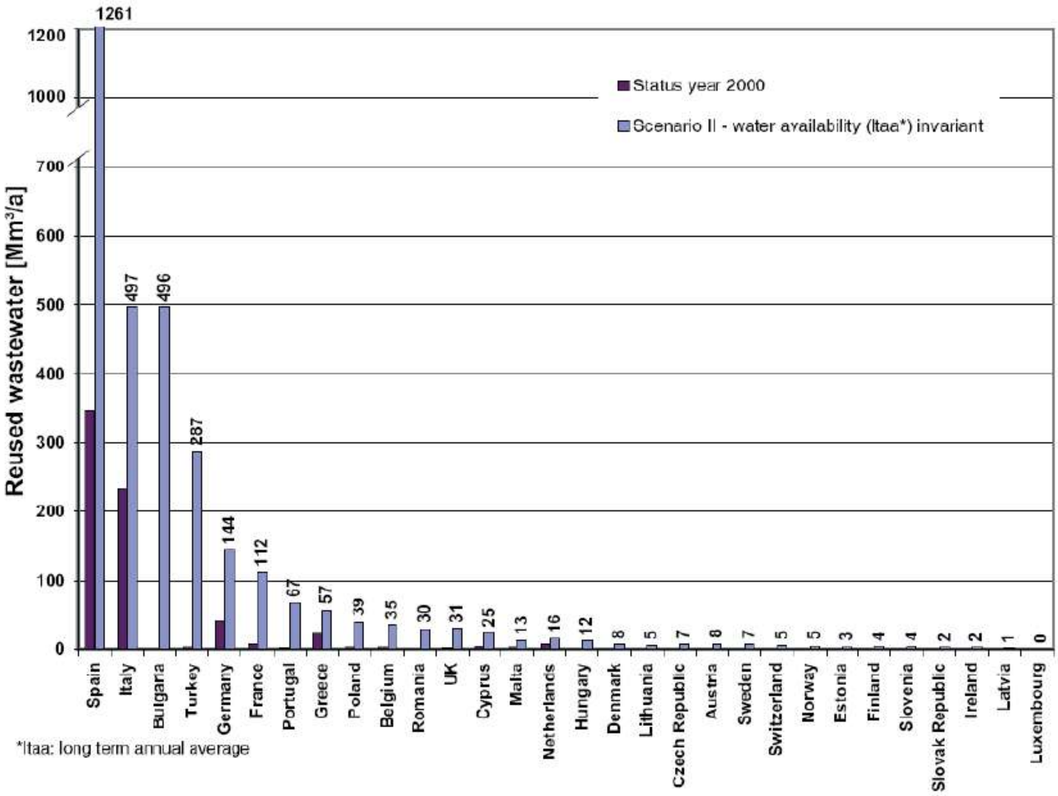
However BIO (2015) estimated that, if no further EU policy action is to take place to promote reuse of treated wastewater, a volume of around 1,700 million m^3/year could be reached by 2025. This was based on the assumptions that:

- The water reuse target for Spain (1,200 million m^3/year) is achieved by 2018; and
- No increases in treated wastewater reuse would take place in other Member States in comparison to the current situation.

[77] The Aquarec model has been developed to quantitatively assess the potential for waste water reuse based on a mass balance approach describing the flows of reuse water and reclaimed waste water. The amount of WWTP effluent reclaimed is assumed to equal the amount reused while covering a particular fraction of total demand http://www.iwrm-net.eu/sites/default/files/Aquarec_Policy%20Brief_final_A4.pdf

[78] Global Water Intelligence, 2015, Vol I summary

Figure 3.4 AQUAREC model output for wastewater reuse potential of European countries on a projection horizon of 2025 (Scenario II presents projection to 2025)



Source: Hochstrat et al., 2006 quoted in BIO (2015)

The AQUAREC result, and by extension the BIO estimates, can be put into perspective by comparing them with some estimates developed by national authorities.

The only three Member States which are known to have estimated their water reuse potential are Spain and Cyprus:

- In **Spain**, it is expected that water reuse could increase from around 500 million m^3/year (current situation) up to around 700 million m^3/year (without further policy intervention), and could reach a maximum level of approximately 1,200 million m^3/year by 2018 if more awareness raising and information-related initiatives were put in place by the government[37]. The target of 1,200 million m^3/year by 2018 is included in the National Water Reuse Plan which is yet to be formally adopted. This is similar to the potential estimated by AQUAREC for 2025. It represents approximately 4% of the country's total annual water abstraction; and
- In Cyprus, a total volume of 78.4 million m^3/year of treated municipal effluents is expected by 2027 (compared to about 30 million m^3/y in 2013), almost 90% of which is expected to be reused (for irrigation and aquifer recharge). This figure is much higher than the potential estimated by AQUAREC for 2025 (25 million m^3/year).

For other countries, there is a lack of information to verify the AQUAREC estimates, however it is worth noting that:

- In **Bulgaria**, the high potential for 2025 estimated by AQUAREC (496 million m^3/year) seems very optimistic considering that the 2000 level of reuse is quasi null. There is no significant increase of reuse expected in the near future, because the treatment processes in urban WWTPs are not yet sufficient to produce reclaimed water of sufficiently high quality. Furthermore, Bulgaria is among the Member States with the lowest compliance rates with regard to the UWWTD's wastewater collection requirements (below 30% in 2009/2010) (EC, 2013 quoted in BIO, 2015);

- In France, Italy and Greece, the case studies (see Appendix D) identified no significant increase in water reuse is expected in the future due to the high administrative burden and complexity associated with the application of the current national standards, which creates disincentives to the development of new schemes. In addition, in Greece, preliminary information from experts indicates that the AQUAREC estimate for 2025 (57 million m^3/year) may be difficult to achieve in a cost-effective way; and
- In Portugal, only about 1% of treated wastewater was reused in 2011 (6.1 million m^3/year) and the situation has not changed significantly since then. A new water reuse target might be set in the forthcoming national strategic plan (PENSAAR 2020). According to national stakeholders, under a business as usual scenario the situation is not expected to change significantly in the near future, due to a number of obstacles (lack of economic incentives, insufficient public awareness and acceptance and high administrative burden to obtain permits).

While numerous publications have stressed the significant potential for increasing water reuse in the EU, none of these publications has quantified the level of reuse that could be achieved in the case of stronger policy incentives. Quantifying the potential for increasing water reuse at the EU level is difficult, because water reuse is a local solution: the maximum level of reuse that could be achieved in a cost-effective way is very much dependent on local specificities such as the distance between supply and demand (e.g. between WWTPs and users) and the socio-economic context (BIO, 2015).

Under the baseline scenario of this study supporting the Commission's impact assessment, and in continuity with the previous study supporting the Commission's impact assessment, it is assumed that no new EU action specific to treated wastewater reuse will be developed. This means that the current state of national, legislation and approaches with related barriers and little incentive to reuse water would be continued. Finally, the baseline scenario assume an improved implementation of the existing EU water policy framework (especially as regards water pricing and control of abstractions) which could be expected to increase the uptake of water reuse. However as the comparison between the AQUAREC estimate and the actual Member States' estimates already indicate, this baseline scenario may lead to an uptake much below its potential development and benefits to the economy and the environment (BIO, 2015).

3.6 Possible justification for EU action

The Better Regulation guidelines indicate that EU action can be justified against three key aspects: competence of the EU to act, subsidiarity and effectiveness.

Competence

Under Article 191 of the Treaty on the Functioning of the European Union (TFEU) related to the protection of the environment, EU action is to contribute to: "preserving protecting and improving the quality of the environment, protecting human health, prudent and rational utilisation of natural resources and promoting measures at international level to deal with region or worldwide environmental problems, and in particular combating climate change".

EU action would aim at ensuring a high level of protection of health and the environment through the enabling of safe water reuse.

Subsidiarity

Subsidiarity is an underlying principle for EU action inscribed in Article 5 of the Treaty on the European Union. It aims to ensure that decisions are taken as closely as possible to the citizen and that constant checks are made to verify that action at EU level is justified in light of the possibilities available at national, regional or local level. It should be noted that **60% of EU river basins are international**, shared between two or more countries (and 19 in the case of the Danube). Action taken by a single or a few Member States is therefore not sufficient, for instance in relation to quantitative aspects of water management or cross-border water pollution. This is particularly relevant for groundwater aquifer recharge.

For other uses, the decision to conduct water reuse is a Member State level decision reflecting on the national and local specificities. However it is important to note that in the presence of single market issues (which could be the case with agriculture irrigation) then subsidiarity becomes relevant. Moreover, if Member States act alone, the technical barriers and associated costs are likely to be unnecessarily high (BIO, 2015).

It is worth noting that the public consultation showed support of Member States for EU measures. This was considered by almost all of those who expressed an opinion (except Germany) as a **legitimate component of EU action**[79]. More than 90% of respondents from Member States with standards indicated that legally binding EU level standards would be effective or very effective for ensuring environmental and health safety of water reuse.

Finally and most importantly, action at EU level **could provide flexibility to allow Member States to decide whether to pursue water reuse in practice**. There are several flexibilities that an EU policy instrument could adopt to be an 'enabler' of water reuse by ensuring a systematic consideration of this alternative supply route and develop measures to ensure coherence, should Member States decide to develop treated wastewater reuse schemes and to set requirements for their respective jurisdictions. (BIO, 2015)

Effectiveness

Through the barriers to treated wastewater reuse identified, a common limitation is the lack of an EU-wide approach to support the development of water reuse practices. As such EU action could:

- Support water reuse and increase its acceptability by formally endorsing it at EU level;
- Harmonise the current practices and avoid national standards being used as trade barriers for agricultural foods;
- Reduce health and environmental risks by ensuring a high level of health and environmental protection; and
- Provide industry with a strong signal of support to unlock investments in R&D and further innovation.

Action at EU level is consistent with the application of the CIS guidelines developed in this project to support Member States intending on introducing water reuse schemes. In particular, the guidelines would provide support to Member States with how to apply possible standards. A minimum quality included in the legislative action would allow a high level of protection to water uses and the environment to be ensured while harmonising water reuse schemes across the EU.

Stakeholders to the public consultation held in 2014 saw EU action as the most effective way to promote water reuse. Almost 80% of the respondents considered that regulatory action was needed at EU level. Interestingly, respondents from Member States with existing standards for water reuse were more supportive with 91% of them viewing EU action as effective or very effective. Several Member States indicated that a harmonised EU approach would support better implementation of the standards in their Member States, making reuse projects easier to implement and attracting confidence for investments. Conversely, around 75% of the respondents indicated that maintaining the status quo would not be effective in promoting water reuse[80]. While this feedback is not enough in itself to justify EU action, it provides an indication on the perception of the needs for future action.

Water reuse in agricultural irrigation is one of the areas of highest potential for increased uptake, but is affected by different requirements set under individual national jurisdictions. Member State specific requirements are not contributing to the creation of a level playing field and may lead to **obstacles to the internal market, especially for agricultural products**. Common water quality requirements would allow the

[79] BIO, 2015, Public consultation report on optimising water reuse

[80] BIO, 2015, Public consultation report on optimising water reuse

quality of products irrigated with reused water and the safety of workers and consumers to be ensured. Furthermore, the application of water quality requirements could ensure a higher level of security for agricultural activities using reused water and help facilitate investments in the sector.

Disparities in the existing treated wastewater reuse standards (which are currently in place in six Member States) also generate differences in the production costs of food products. Additionally different standards might also be used as an argument to restrict the import of food products from Member States suspected of having lower standards. Such disparities may also create potential barriers to internal trade and to the functional operation of the single market. In this respect, some of the arguments put forward in the preamble of EU Regulation No 178/2002 on food safety are also relevant to the present assessment, in particular:

- 'The free movement of safe and wholesome food is an essential aspect of the internal market and contributes significantly to the health and well-being of citizens, and to their social and economic interests';
- 'The free movement of food and feed within the Community can be achieved only if food and feed safety requirements do not differ significantly from Member State to Member State'; and
- 'There are important differences in relation to concepts, principles and procedures between the food laws of the Member States. When Member States adopt measures governing food, these differences may impede the free movement of food, create unequal conditions of competition, and may thereby directly affect the functioning of the internal market.'

Finally, several of the potential benefits from water reuse match EU wide initiatives. For example the potential reduction of reliance on energy-intensive processes such as desalination and water import could lead to reductions in greenhouse gas emissions. The reduction of GHG emissions by 80% below 1990 levels by 2050 is an EU level objective placed by the low-carbon economy roadmap adopted by the European Commission in 2011[81]. As such, actions to facilitate water reuse at EU level could contribute to reducing GHG emissions. Similarly, the development of a resource efficient community is supported by the Communication on a circular economy. Increasing the uptake of water reuse would match the objectives of this initiative by encouraging better use of resources, including potential reuse of nutrients.

EU interventions with regards to water reuse have already been adopted in some areas. For example, EMAS (the European environmental management system) identified for the construction sector that the harvesting of rainwater and grey water from roofs for recycle and reuse purposes is a Best Environmental Management Practice (BEMP)[82]. The reuse of water in the tourism sector is a well-established BEMP described in a recent best practice report from the JRC[83]. As such further EU intervention could build synergies with existing EMAS practices.

[81] European Commission, 2011, Toward a low carbon economy. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0112&from=EN
[82] Decision (EU) 2015/801 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015D0801&from=EN
[83] JRC, 2013, Best Environmental Management Practice in the Tourism Sector, http://susproc.jrc.ec.europa.eu/activities/emas/documents/TourismBEMP.pdf

4. Policy options for the promotion of water reuse for agriculture irrigation and aquifer recharge

4.1 Policy objectives

4.1.1 General policy objective

The general policy objective assessed here, designed to address the identified barriers to the increase of water reuse, is to encourage efficient resource use and reduce pressures on the water environment, in particular water quantity issues related to water scarcity, by fostering the development of safe reuse of treated wastewater. This means achieving a higher uptake of appropriate water reuse solutions, where it proves cost effective (taking into consideration the wide range of potential costs and benefits), while ensuring the safety of reuse practices (i.e. providing a high level of confidence in the management of human health and environmental risks associated with reuse practices) and avoiding potential internal trade barriers for food products irrigated with reclaimed water.

To this end the policy initiative would aim at establishing a common approach to water reuse across the EU, providing clarity, coherence and predictability to market operators who wish to invest in water reuse in the EU under comparable regulatory conditions.

Additional objectives of the initiative would be – where suitable and possible and acknowledging its limitations – to increase the recycling of nutrients contained in waste water, and to contribute to growth and jobs creation in the EU by stimulating the development of innovative technologies and water infrastructure that will provide EU actors with a first-mover advantage in this fast growing world market.

Such a policy would complement the existing EU water policy, notably the Water Framework Directive and the Urban Waste Water Treatment Directive.

The initiative should be providing Member States with a clear and safe framework to develop water reuse practices if they wish to, however acknowledging that the decision to opt for water reuse practices is the Member State own decision.

4.1.2 Specific policy objectives

The following specific policy objectives are defined:

- O1: Promote treated wastewater reuse as an integral part of integrated water management measures to deliver water management objectives;
- O2: Protect groundwater bodies and surface water bodies from unsustainable exploitation and prevent their degradation through increased nutrient levels and pollutants; i.e. achieve good quantitative and chemical status;
- O3: Prevent potential internal trade barriers for agricultural products irrigated with treated wastewater and facilitate access to the single market for agricultural products grown using treated wastewater for irrigation across the various national regulatory regimes within the European Union;
- O4: Protect the health of EU citizens and the environment by addressing actual and perceived risks associated with reusing treated wastewater through:
  - Building trust, credibility and confidence in the quality of reclaimed water among the general public by addressing the lack of EU wide, uniform water quality standards (for non-potable purposes); and
  - Providing clarity on how to manage public health and environmental risks of water reuse projects in the EU.

- O5: Explore the range of policy options available to establish a level playing field for treated wastewater users across the EU thereby improving investors' confidence and promoting investment in water reuse infrastructure;
- O6: Promote an increased use of economic instruments to make treated wastewater reuse schemes more economically attractive;
- O7: Increase knowledge on the benefits and drawbacks of water reuse among the various stakeholders; and
- O8: Improve scientific knowledge and technical expertise in the field of water reuse.

The table below presents the links between the objectives defined and the barriers identified.

Table 4.1 Overview of policy objectives and barriers identified

Specific policy objectives	**Barriers addressed by the objectives**			
	Possible trade barriers due to lack of harmonised legislation	**Water reuse is perceived as being more risky than beneficial**	**Water reuse is more expensive than conventional resources**	**Other barriers**
O1: Promote treated wastewater reuse as an integral part of integrated water management measures to deliver water management objectives	√	√	√	
O2: Protect groundwater bodies and surface water bodies from unsustainable exploitation and prevent their degradation through increased nutrient levels and pollutants; i.e. achieve good quantitative and chemical status;	√	√	√	√
O3: prevent potential internal trade barriers for agricultural products irrigated with treated wastewater and facilitate access to the single market for agricultural products grown using treated wastewater for irrigation across the various national regulatory regimes within the European Union	√	√	√	√
O4: Protect the health of EU citizens and the environment by addressing actual and perceived human health risks associated	√	√		√
O5: Explore the range of policy options available to establish a level playing field for treated wastewater users across the EU thereby improving investors' confidence and promoting investment in water reuse infrastructure	√			√
O6: Promote an increased use of economic instruments to make treated wastewater reuse schemes more economically attractive	√	√	√	
O7: Increase knowledge on the benefits of water reuse among the various stakeholders		√		√
O8: Improve scientific knowledge and technical expertise in the field of water reuse		√		√

Possible measures to achieve objectives

A range of policy measures have been identified under the previous study to support the Commission's impact assessment and further explored as part of this current study. Some only partially address some of the objectives defined. The table below presents the list of policy measures against the objectives and provides justifications on why some of these were not retained for the purpose of this report.

Table 4.2 Overview of policy measures linked to objectives identified

Possible EU measure	Decision on further action	Justification
Increase the level of enforcement of WFD requirements concerning water pricing (Art. 9) and freshwater abstraction (Art. 11)	Not pursued further	This measure goes beyond the scope of water reuse and is a key action identified under the Blueprint. As such, it is considered that separate action may be best suited
Integrating water reuse in the codes of Best Practices in agriculture. This would consider integration of water reuse at EU level, and in particular to ensure good management of reused water and fertilisers at farm level.	Not pursued further	This measure goes beyond the agreed scope of this work but could be considered in further work.
Improve implementation and enforcement of the WFD with regard to integrated water management and better governance (e.g. cooperation between water supply and sanitation stakeholders)	Not pursued further	This measure goes beyond the scope of water reuse and is a key action identified under the Blueprint. As such, it is considered that separate action may be best suited
Develop EU guidelines to support the design and implementation of the right price structure and level for water reuse - these guidelines would include recommendations in order to address market failures that currently limit the uptake of water reuse solutions	Not pursued further	EU guidelines have been developed as part of the CIS process, as such there was no need to further review the suitability of such action to water reuse
Organise awareness raising campaigns, develop awareness raising tools and disseminate information on the various benefits and drawbacks of water reuse, among all key stakeholders	Not pursued further	This measure goes beyond the agreed scope of this work but could be considered in further work.
Develop a good practice reference document on water reuse, resulting from a knowledge exchange between Member States and other stakeholders	Addressed by CIS guidelines	EU guidelines have been developed as part of the CIS process. As such there was no need to further review the suitability of such action to water reuse
Include water reuse - other than internal recycling - as a key aspect to be considered in the definition of Best Available Techniques (BAT), so that it is taken into account in the development of future Best Available Techniques Reference Documents (BREFs) and progressively integrated into the provisions of new permits issued under the Industrial Emissions Directive (IED). This could cover both the use of externally produced reclaimed water by an industrial plant and the production of reclaimed water by an industrial plant for external uses.	Addressed by action plan	A specific action under the EU action plan for water reuse considers integrating water reuse in existing industrial processes in particular in the BREFs.
Develop guidance on the use of European Structural and Investment Funds (ESIF) supporting projects to comply with the UWWTD.	Addressed by action plan	A specific action under the EU action plan for water reuse considers increased research and innovation
Include water reuse in the scope of future implementation reports of the UWWTD, so that accurate information is made available on the current status and future potential for water reuse.	Considered in the study	This integration has been considered in this study as a way to enhance policy effectiveness

Possible EU measure	Decision on further action	Justification
Establish minimum quality standards which must be achieved if water reuse is to be conducted (with several possible approaches) for the most supported and promising uses (agriculture irrigation and aquifer recharge).	Considered in the study	This measure would consider both non-binding and binding options and different level of stringency for legally binding standards for both agricultural irrigation and aquifer recharge.
Contribution of water reuse to soil fertilisation to be taken into account in the EU legislation on fertilisers	Not progressed further	A proposal for a new Regulation on fertilisers was published, it deals primarily with internal market of fertilisers and water reuse did not fit in the scope.
Include water reuse in good environmental condition rules under the cross-compliance mechanism of the CAP	Not progressed further	This measure was considered concluded to be not feasible due to the recent CAP reform.
Support innovation in reclamation technologies and the up-skilling of EU professionals in the water sector **Support research related to emerging pollutants in reuse schemes and their fate (impact on soil, health and environmental effects, etc.)**	Addressed by action plan	A specific action under the EU action plan for water reuse considers ways to improve access to funding from EU programmes and stimulate innovation and R&D.

4.2 Consideration of policy options

4.2.1 Regulatory or non-regulatory options

The selection of policy options considered the alternatives of regulatory and non-regulatory measures and both are considered as part of this study.

The Better Regulation toolbox defines 4 broad categories of policy instruments:

- Legally binding rules (hard);
- (Soft) regulation;
- Education and information; and
- Economic instruments.

These categories were reviewed against the objectives identified.

A binding instrument would be more burdensome to adopt / implement and could have more impacts on those Member States that already have national legislation, as they would most likely need to undertake changes to match the binding instrument's approach. However, this category of instrument would be an option suited to addressing single market issues. A binding instrument, depending on its content, could address all the objectives identified.

Article 288 of the TFEU establishes three types of binding acts. These are described in the Better Regulation toolbox as follows:

- ***Regulations*** are directly applicable in all Member States and binding in their entirety so they do not need to be transposed. Regulations are used most commonly where it is important to achieve uniform implementation of a policy intervention such as in the internal market or the governance of mergers;
- ***Directives*** are binding on the Member States to which they are addressed in respect of the result to be achieved but the specific form and methods are left to national authorities to decide.

Directives should, as far as possible, be general in nature and cover the objectives, periods of validity and essential requirements; and

- ***Decisions*** are binding in their entirety on those to whom the Decision is addressed (e.g. individuals, companies or Member States).

Soft instruments could be less burdensome to apply (most being voluntary), however most would not be able to address single market issues, nor harmonise Member States practices with the exception of technical standards, however these would need to be adopted by an official standardisation office to be binding Rather these could provide a common reference for all Member States to use when considering their own approach to water reuse. As such a non-binding instrument, depending on the content, could address specific objectives O1, O2, O7 and O8 (cf. table 4.1) and to some extent O4, but could not address objectives O3 and O5.

The Better Regulation toolbox describes the following ('soft') instruments:

- Recommendation to encourage a specific type of behaviour or outcome without being binding. These enable the Commission to establish non-binding rules. They are described as an alternative where not enough evidence is available on the need for a legislating binding instrument;
- Technical standards are voluntary documents developed by one of the three recognised standardisation bodies (the European Committee for Standardisation (CEN), the European Committee for Electrotechnical Standardisation (Cenelec) or the European Telecommunications Standards Institute (ETSI)). Once a European standard is developed and agreed, the National standardisation bodies, who are members of the ESOs, must transpose it as a national standard and they must withdraw all conflicting national standards. Standards set out specifications and other technical information with regard to various kinds of products, materials, services and processes. Standardisation is described as a 'key instrument for consolidating the Single Market, supporting competitiveness of European industry at global market, harmonising conflicting national standards and facilitating cross-border trade in a less intrusive manner than technical regulations[84]'; and
- Self-regulation initiatives are when business or industry sectors formulate codes of conduct or operating constraints on their own initiative which they are responsible for enforcing. The Commission notes that self-regulation in this form is rare.

Education and information tools would increase knowledge and acceptance of water reuse in Europe, in particular addressing objectives O4, O7 and O8. However this would likely not achieve the other objectives identified, in particular those related to the single market.

Finally the economic instrument option includes taxes, charges, fees, fines, penalties and compensation schemes however this does not appear to be suited to the issue being considered.

Beyond the choice of the most suited instrument it is important to consider the differences between binding and non-binding approaches, and between minimum and harmonised standards, all of which could be possible option. The table below summarises the pros and cons of each possible combination when applied to water reuse.

[84] Better Regulation toolbox, Tool #15, http://ec.europa.eu/smart-regulation/guidelines/tool_15_en.htm

Table 4.3 Considerations of instrument type

	Pros	Cons
Non-binding minimum standards	• Low administrative burden for Member States as this is voluntary, so up to them to meet the standards or not; and • Support better understanding and knowledge of water reuse by providing an EU wide approach.	Member States do not have to take the standards into account This would not address any Single Market issue
Non-binding harmonised standards	Harmonisation requires a binding initiative as it prioritises the EU approach over the national approaches	
Binding minimum standards – Regulation	• Administrative burden reduced as it does not require formal transposition into national legislation, however it would require interested Member States to adapt their existing legislation / practices; • Support better understanding and knowledge of water reuse by providing an EU wide approach; and • Better acceptance from Member States as seen as more flexible.	• May not fully address possible Single Market barriers: o Member States can decide to retain their more national stringent standards; and o Member States can decide to require other parameters than those included in the EU Regulation.
Binding minimum standards – Directive	• Support better understanding and knowledge of water reuse by providing an EU wide approach; and • Better acceptance from Member States as seen as more flexible.	• Administrative burden due to the need to formally transpose the instrument into national legislation, even if the Member State does not intend on developing water reuse; and • May not fully address possible Single Market barriers: o Member States can decide to retain their more national stringent standards; and o Member States can decide to require other parameters than those included in the EU Directive.
Binding harmonised standards - Regulation	• Administrative burden reduced as it does not require formal transposition into national legislation, however it would require interested Member States to adapt their existing legislation / practices; • Support better understanding and knowledge of water reuse by providing an EU wide approach; and • Address single market barriers as: o Member State cannot retain more stringent national standards; and o Member State cannot require standards on other parameters.	• Lower acceptance from Member States as seen as less flexible.
Binding harmonised standards - Directive	• Support better understanding and knowledge of water reuse by providing an EU wide approach; and • Address single market barriers as: o Member State cannot retain more stringent national standards; and o Member State cannot require standards on other parameters.	• Administrative burden due to the need to formally transpose the instrument into national legislation, even if the Member State does not intend on developing water reuse; and • Lower acceptance from Member States as seen as less flexible.

Based on the comparison above, a binding minimum or harmonised standards instruments would be most likely to achieve the objectives, and a Regulation would be the least burdensome by avoiding transposition into national legislation as required by a Directive.

The nature of a possible policy instrument was considered in the public consultation organised under the previous support contract[85]. Non-regulatory measures were favoured by countries where water scarcity is not an issue and where there is no existing national legislation (Finland, the Netherlands and the UK). Finland and the Netherlands indicated that EU action should focus on encouraging tailor-made approaches through guidance and best practices, because of the high variability of environmental conditions among the Member States. Furthermore, the UK considered that the main barrier to water reuse is linked to lack of awareness of the benefits, so that providing guidance and sharing best practices would be beneficial.

However regulatory measures were seen as a favoured option for countries where water reuse is currently practiced or expected (France, Italy, Spain, Cyprus and Estonia). In particular, it was highlighted that while voluntary measures and guidance could be useful these would not address the main barriers considered which included the risk of potential trade barriers and the lack of coherent legal framework. France considered that guidelines should be a last resort option only if no agreement can be reached on a regulation.

Regulatory measures are supported if these raise opportunities for reuse; however a framework setting minimum targets for water reuse was not supported (France and Netherlands).

From the public consultation feedback, **the most supported regulatory measure was to set legally-binding minimum standards**, with the aim to create a level-playing field in the EU and to manage health and environmental risks efficiently. Moreover, Czech Republic and Estonia, where water reuse practices are still rare but expected to grow in the future, considered that EU regulatory measures would be effective in promoting water reuse and ensuring its safety.

4.2.2 Consideration on reporting on the instrument implementation (monitoring and evaluation)

The Better Regulation guidelines have reinforced the commitment from the Commission to monitor the implementation of legislative instruments. This requires monitoring at national level to ensure that the intervention performs as intended and to identify options to improve it further. The objectives of monitoring and reporting are described as:

- To demonstrate compliance with a legal obligation;
- To determine if the objectives of legislation are being achieved effectively and efficiently, including, where appropriate, ensuring a level playing field of the internal market;
- To inform the other EU institutions as well as the public and stakeholders at EU level on the progress of implementation and the identification of gaps;
- To help inform the understanding of an environmental issue and so help to improve decision making, e.g. policy evaluations or impact assessments; and
- To identify and spread good practices amongst Member States.

Furthermore, in March 2016, the Commission published a Roadmap for a Fitness Check of monitoring and reporting obligations in environment policy[86]. The Roadmap supports the following objectives: better implementation and compliance rates; better information and empowerment of citizens through increased transparent and publicly available information; facilitating evidence needed for the evaluation of the policy cycle; and lowering the costs and burden for those providing the information. The policy instrument design should take these objectives into account.

The main objective of monitoring the implementation and effectiveness of the policy intervention on water reuse would be to inform the Commission with the evolution of reuse uptake in Member States and in Europe. In addition, other benefits could be achieved with the reporting such as:

[85] BIO, 2015, Report on public consultation

[86] Roadmap for a Fitness Check of monitoring and reporting obligations in environment policy http://ec.europa.eu/environment/legal/reporting/pdf/2017_env_002_monitoring_and_reporting_obligations_en.pdf

- Identify whether the quality requirements set by the EU are being applied by Member State and consistently across the EU;
- Identify the best practices being applied by Member States;
- Identify implementation problems (e.g. possible high costs of sampling and testing to comply with quality monitoring); and
- Identify whether further action is required.

Reporting requirements can be included in non-binding and binding instruments; however for the former, reporting is mostly voluntary. In a binding instrument, reporting could be made compulsory.

A way of simplifying reporting requirements would be to merge reporting on water reuse with another related reporting requirement. For example treatment plant operators could be required to add data on water treated for reuse to their reporting under the Urban Waste Water Treatment Directive. Art. 15.4 of the UWWTD requires information on discharges from WWTPs to be collected by competent authorities and for this to be made available to the Commission. This has since been elaborated and Member States and the Commission have jointly developed technical specifications for such reporting within WISE[87]. Included within this is reporting under an agreed format on reuse of water from the WWTPs. This reporting is currently limited to general questions on whether reuse is conducted, the rate of treated waste water reused and the types of reuse done[88]. However it could be extended to include further information.

Synergies with existing databases (e.g. PRTRs, ichem[89]) could also be considered on a voluntary basis. In spring 2016 the JRC launched the ‘ichem’ web-portal which was developed in collaboration with international agencies (e.g. EFSA, ECHA) and national agencies (e.g. UBA). The database acts as the repository for a number of monitoring data-sets for a wide range of chemicals in the natural environment including water emissions data.

On the generation of data for reporting, the policy instrument (either binding or non-binding) could specify that water quality data be generated for the purpose of monitoring. These data could also be made available to the public, which would deliver an additional information / educational benefit from the reporting requirement. Once generated, the Member States’ competent authorities could collect the data in a pre-agreed format and communicate this to the Commission.

Operators of WWTPs and potentially water reuse users could be required to generate the data and report it to their national competent authority. Member States competent authorities would then communicate these results to the Commission. There would then be a need for Member States to establish a requirement that operators provide their quality monitoring data. It is appropriate to consider a system where, if operators do not elect to reuse water, no information would need to be reported.

Measures could be taken so that generation, collection and transmission of data (by operators and competent authorities) represents as low a burden as possible, making use of existing reporting streams. For example, capturing the data electronically at the point of origin (i.e. data from operators) is less expensive than periodic nationwide surveys.

The timing of the reporting would also need to take into account that the initiative may need a few years of practical implementation before meaningful information can be reported back, in particular on shortcomings and best practices. The UWWTD reporting under WISE is required every 24 months.

4.3 Overview of selected policy options

Based on the objectives and measures identified in the previous section, the following policy options were identified as the most viable and were selected for assessment. This selection takes into account that

[87] See: http://rod.eionet.europa.eu/obligations/613/overview
[88] http://cdr.eionet.europa.eu/help/UWWTD/UWWTD_613

[89] https://ipchem.jrc.ec.europa.eu

several of the possible measures have been addressed by the recent non-regulatory actions included in the water reuse action plan published as part of the circular economy Communication (cf. section 2.2).

While future policy developments beyond this initiative might cover other uses for which reuse of treated wastewater can be promoted (such as irrigation of green urban areas or reuse of grey water) the envisaged options will focus on the two uses identified by the Circular Economy Action plan for their greatest potential in terms of scarcity alleviation and EU relevance: agriculture irrigation and aquifer recharge.

The source of water to be reused is only the wastewater covered by the Urban Wastewater Treatment Directive (91/271/EEC), that is to say urban wastewater and industrial wastewater from the industrial sectors listed in Annex III of the UWWTD.

Policy options consider minimum quality standards, that is to say minimum standards to ensure the safety of reused water.

However based on later discussion with IASG, there may be a need to consider the use of harmonised standards. As presented in Table 4.4, harmonised standards would be best suited to address Single Market barriers as they would prevent Member States from requiring stricter quality requirements than those agreed at EU level and would prevent Member States from requiring other quality requirements than those agreed at EU level, both of which could constitute barriers. Due to this consideration arising at a later stage of the project, harmonised requirements are not considered in the policy options used for the assessment of impacts. However we included in Section 4.2 initial observations on possible expected impacts from harmonised requirements.

Policy options (beyond a 'do nothing' baseline) are proposed for both agriculture irrigation and aquifer recharge.

4.3.1 Agriculture irrigation

Three policy options are considered, two of which are designed to achieve the overall policy objectives:

- Ag 1. Baseline;
- Ag 2.Develop and/or promote non-binding (water quality) standards (minimum) for water reuse; and
- Ag 3.Develop legally binding (water quality) standards (i.e. minimum) for water reuse.

Specific details on proposed risk management plans, treatment standards, treatment process controls, application controls and water quality benchmarks are provided in Appendix A. This appendix summarises and simplifies an initial draft from the JRC on possible standards. It is important to note that this draft has had substantial changes since.

4.3.2 Aquifer recharge

Three policy options are considered, two of which are designed to achieve the overall policy objectives:

- Aq 1. Baseline;
- Aq 2. Develop and/or promote non-binding (water quality) standards for treated wastewater used to recharge aquifers; and
- Aq 3 Develop binding (water quality) standards for treated wastewater used to recharge aquifers.

Specific details on proposed risk management plans, treatment standards, treatment process controls, application controls and water quality benchmarks are provided in Appendix A. Here again, it is important to note that the technical work from the JRC has evolved and that the draft has had substantial changes made to since.

4.4 Presentation of policy options

4.4.1 Policy options for water reuse in agriculture irrigation

Three policy options are considered for agriculture irrigation as shown below[90].

Table 4.4 Overview of options considered

Instrument type	Quality requirements for water reuse for irrigation
Business as usual - baseline	Option Ag 1.
Guidance/Recommendation	Option Ag 2. Development and promotion of non-binding standards for water reuse for agricultural irrigation
Legislative option	Option Ag 3. Development of legally binding standards for water reuse for agricultural irrigation

Policy Option Ag.1 is a non-interventionist option, reflecting the baseline scenario. The outcomes in terms of changes in agricultural reuse activity will be a consequence of national and EU policies already in place including how those policies may change in the absence of new, additional EU-level actions. Most importantly, the option considers current and future uptake rates of using reclaimed water in agricultural irrigation across the EU and associated environmental, economic and social impacts associated with Business as Usual treated wastewater reuse development. This option also considers that other actions (e.g. integration of reuse in BREF) under the circular economy action plan will go ahead.

Policy Option Ag. 2 would introduce a non-legally binding document (e.g. guidance or recommendation) stipulating minimum quality requirements for using reclaimed wastewater for agricultural irrigation taking into account health and environmental risks. The level of stringency of the water quality standards would be determined for different crop categories (i.e. different risk receptors) including:

- Food crops to be eaten raw (this may be sub-divided between root vegetable and tree fruits);
- Food crops that will be cooked or processed; and
- Non-food crops

Many factors affect the uptake by crops of potentially hazardous contaminants within treated effluent, the exposure routes, and the ultimate human health risks and risks for the environment. The non-legally binding document would take these factors into account when specifying minimum quality requirements and the range of risk management measures.

Minimum quality requirements would be proposed as guidance without being mandatory. The costs and benefits of this policy option would be influenced by the impact on uptake of a voluntary measure. There would be no policy **monitoring and evaluation** costs associated with a non-binding initiative as any reporting to the European Commission on the application of the guidance would be voluntary.

Policy Option Ag. 3

This option would involve developing a legally binding document (i.e. a Regulation or a Directive) setting out quantifiable minimum water quality requirements that must be complied with when using treated wastewater in agricultural irrigation taking into account health and environmental risks. The level of stringency of the water quality standards would be determined for different crop categories (i.e. different risk receptors) including:

[90] While three options have been defined for agriculture irrigation and aquifer recharge, note options 2 and 3 could be further divided into sub-options depending on the level of stringency of the quality requirements to be aimed at, linked, for example, to the crops to be irrigated or the potential use of the recharged aquifers.

- Food crops to be eaten raw (this may be sub-divided between root vegetable and tree fruits);
- Food crops that will be cooked or processed; and
- Non-food crops.

This option includes specifying quality requirements for water to be used for irrigation, and risk management measures that must be complied with. The option consider minimum quality requirements. The legislative instrument would not set mandatory targets for water reuse (i.e. minimum percentage of agricultural irrigation to be carried out using reused water).

This option requires monitoring and evaluation activity and these costs are assessed. Note that this policy option is based on an initial draft that assumed that water quality monitoring is performed the point of discharge from the treatment plant and would include the following parameters:

- Microbial contaminants:
  - Viruses;
  - Bacteria; and
  - Parasites and other pathogens.
- Physico-chemical contaminants:
  - Total suspended solids (indication of secondary treatment effectiveness);
  - Turbidity (indication of the filtration effectiveness and suitability for disinfection); and
  - Biochemical Oxygen Demand (BOD, indication of secondary treatment effectiveness).

Calculation of monitoring costs takes into account monitoring frequency, sampling, and laboratory costs.

In addition, costs of monitoring of the implementation and effectiveness of the option are also taken into account through administrative costs.

4.4.2 Policy options for water reuse in aquifer recharge

Three policy options are considered for aquifer recharge[91].

Table 4.5 Policy options to increase aquifer recharge using reclaimed water

Instrument type	Minimum quality requirements for reuse in potable and non-potable aquifers
Business as Usual - Baseline	Option Aq 1
Guidance / Recommendation	Option Aq 2 Development and promotion of non-binding standards for water reuse for aquifer recharge
Legislative option	Option Aq 3 Development of legally binding standards for water reuse for aquifer recharge

The options consider recharge of aquifers associated with potable and non-potable uses.

[91]While three options have been defined for agriculture irrigation and aquifer recharge, note that for options 2 and 3 are further divided into sub-options dependant on the level of stringency of the quality requirements to be aimed at, linked, for example, to the crops to be irrigated or the potential use of the recharged aquifers.

Policy Option Aq 1 is a non-interventionist option, reflecting the baseline scenario. The outcomes in terms of changes in aquifer recharge activity would be a consequence of national and EU policies already in place (including any *committed* policy developments) including how those policies may change in the absence of new, additional EU-level actions. Included within this scenario are the existing requirements of the EU Drinking Water Directive 98/83/EC, Groundwater Directive 2006/118/EC, and Water Framework Directive 2000/60/EC.

The outcomes of this policy are measured in terms of the environmental, economic and social impacts associated with Business as Usual activity.

Policy Option Aq 2 would introduce a non-legally binding document (e.g. guidance or recommendation) stipulating minimum quality requirements for using treated wastewater for aquifer recharge. Specified water quality standards would be determined based on the end-use, i.e. whether the aquifer is used as a source of potable water, non-potable water or not at all. Different end-uses require different levels of protection (with environmental compliance standards as a minimum), i.e. the standards proposed would not compromise the objectives and requirements of the GWD, WFD or DWD. The possible non-mandatory Guidance or Recommendation would stipulate sources of wastewater that would be applicable to reuse, and a range of risk management measures.

The costs and benefits of this policy option will be influenced by the impact on uptake of a voluntary measure.

Policy Option Aq 3 involves development of legally binding document (i.e. a Regulation or a Directive) setting out minimum quality requirements to ensure safety of the environment and human health for water reuse to recharge aquifers used to provide potable supply and those that are used for non-potable supply. The scope of such a legislative instrument would not include setting mandatory targets for water reuse (i.e. minimum percentage of aquifer recharge volumes to use recycled water). As per option Aq 2, this policy would specify water quality standards in relation to both aquifer type / use function and the aquifer recharge method applied (e.g. infiltration, direct injection). It would also specify applicable risk management measures and monitoring and evaluation requirements. Mandatory policy requires monitoring and evaluation activity, with associated costs.

5. Economic, social and environmental impacts of policy options

5.1 Introduction

This section presents the economic, social and environmental impacts of the options considered in Section 4. For each option the overall impacts and the impacts identified during the case studies are presented. The extent of the impacts will depend mostly on whether the Member States already have national legislation for water reuse for irrigation and aquifer recharge and whether they will consider adopting these water reuse practices. However, as described previously, the instrument considered (either binding or non-binding) for both uses is an enabling instrument, leaving flexibilities to Member States. As a consequence, for the non-binding option most of the impacts, in practice are expected to be positive or neutral. If negative, Member States would be expected to either keep their own standards or not follow the EU guidance. Furthermore, for the binding options it is possible to design the instrument such as that Member States without national standards and with no interest in reuse practices would remain largely unaffected. This is the case for a Regulation as there would be no transposition needed.

A summary of the impacts associated with different policy options is presented in the table below.

Table 5.1 Summary of the policy impacts

Options	Member States with national standards		Member States without national standards	
	National standards more stringent than proposed	**National standards less stringent / different parameters than proposed**	**Adoption of proposed EU standards**	**Retaining status quo**
Ag1 &Aq1 - Baseline[92]	Environmental: 0 (increased uptake in Spain but not in other MSs) Economic/Administrative: - /0 (increased costs of droughts in MSs affected if no action is taken) Social: -/0		Environmental: 0 Economic/Administrative: 0 Social: -/0	
Ag2 – Non-binding standards Anticipated uptake: low	**If MS choose to retain national standards** Environmental: 0 Economic/ Administrative: 0 Social: 0 **If MS choose to align i.e. lower national standards** Environmental: +/0 (potential for increased uptake volume due to less stringent requirements) Economic/ Administrative: 0 Social: 0/- (public acceptance potentially compromised)	**If MS choose to retain national standards** Environmental: 0 Economic/ Administrative: 0 Social: 0 **If MS choose to align i.e. increase national standards** Environmental: +/- (reduced risks associated with environmental pollutants present in treated wastewater; Reduced uptake volume due to more stringent standards) Economic/ Administrative: -/+ (increased costs of treatment if more advanced processes are needed; improved trade and business opportunities) Social: + (public acceptance boosted)	Environmental: +/0 (increased water availability/ reduced risks associated with environmental pollutants present in treated wastewater /no change) Economic/Administrative: -/+ (increased costs to farmers or WWTP operators/ improved trade and business opportunities) Social: + (promotion of public acceptance)	Environmental: 0 Economic/ Administrative: 0 Social: 0

[92] Expected evolution as presented in the baseline

Options	Member States with national standards		Member States without national standards	
	National standards more stringent than proposed	**National standards less stringent / different parameters than proposed**	**Adoption of proposed EU standards**	**Retaining status quo**
Ag3 – Binding standards Anticipated uptake: medium	**If MS choose to retain national standards** Environmental: 0 Economic/Administrative: 0 Social: 0 **If MS choose to align i.e. lower national standards** Environmental: ++/0 (potential for increased uptake volume due to less stringent requirements) Economic/Administrative: +/0 (possible treatment or monitoring costs savings) Social: 0/- (public acceptance potentially compromised)	**MS align i.e. increase national standards** Environmental: ++/- - (reduced risks associated with environmental pollutants present in treated wastewater; Reduced uptake volume due to more stringent standards) Economic/ Administrative: - -/+ + (increased costs of treatment if more advanced processes are needed; improved trade and business opportunities) Social: + (public acceptance boosted)	Environmental: +/0 (increased water availability/ reduced risks associated with environmental pollutants present in treated wastewater/ no change) Economic/Administrative: - -/+ + (increased costs to farmers/ increased costs for WWTP and farmers / improved trade and business opportunities) Social: + (promotion of public acceptance)	Environmental: 0 Economic/ Administrative: 0 Social: 0
Aq2 - Non-binding standards Anticipated uptake: negligible/ low	**If MS choose to retain national standards** Environmental: 0 Economic/Administrative: 0 Social: 0 (if MS choose to retain national standards) **If MS choose to align i.e. lower national standards** Environmental: +/0 (potential for increased uptake volume due to less stringent requirements) Economic/Administrative: 0 Social: 0/- (public acceptance potentially compromised) ()	**if MS choose to retain national standards** Environmental: 0 Economic: 0 Social: 0 **if MS choose to align i.e. increase national standards** Environmental: +/- (reduced risks associated with environmental pollutants present in treated wastewater; Reduced uptake volume due to more stringent standards) Economic/ Administrative: -/+ (increased costs of treatment if more advanced processes are needed; improved business opportunities) Social: + (public acceptance boosted)	Environmental: + /0 (increased water availability/ reduced risks associated with environmental pollutants present in treated wastewater/ no change) Economic/Administrative: -/+ (increased costs / improved business opportunities) Social: + (promotion of public acceptance)	Environmental: 0 Economic/ Administrative: 0 Social: 0

Options	Member States with national standards		Member States without national standards	
	National standards more stringent than proposed	**National standards less stringent / different parameters than proposed**	**Adoption of proposed EU standards**	**Retaining status quo**
Aq3 -Binding standards Anticipated uptake: low	**if MS choose to retain national standards** Environmental: 0 Economic/Administrative: 0 Social: 0 **if MS choose to align i.e. lower national standards** Environmental: +/0 (potential for increased uptake volume due to less stringent requirements) Economic/Administrative: 0 Social: 0/- (public acceptance potentially compromised)	**MS align i.e. increase national standards** Environmental: +/- (reduced risks associated with environmental pollutants present in treated wastewater; Reduced uptake volume due to more stringent standards) Economic/ Administrative: -/+ (increased costs of treatment if more advanced processes are needed; improved business opportunities) Social: + (public acceptance boosted)	Environmental: +/0 (increased water availability/ reduced risks associated with environmental pollutants present in treated wastewater/ no change) Economic/Administrative: -/+ (increased costs / improved business opportunities) Social: + (promotion of public acceptance)	Environmental: 0 Economic/ Administrative: 0 Social: 0

Legend: 0 – neutral / no change; + to +++ positive/ - to - - - negative (in comparison to baseline); +/ - positive and negative impacts simultaneously associated with different aspects (e.g. water quality and water quantity)

5.2 Option Ag.1 and Aq.1. Business as Usual in water reuse for agricultural irrigation and aquifer recharge

The available data on current and future volumes of reused water under the baseline scenario were analysed in Section 3. The main conclusion is that, under the baseline scenario, the contribution of water reuse towards increasing water availability in the EU will remain limited. Further evidence toward the same conclusions was gathered in a number of case studies as presented in Appendix D.

It should be noted that under the baseline (described in the Section 3) only Spain is expected to increase its water reuse volume to the stated target by 2018. No increases in the uptake of wastewater reuse are anticipated in other Member States.

5.2.1 Environmental impacts

Environmental benefits identified in section 2.1 including specifically the increased availability of freshwater, are unlikely to materialise at a wide scale across the EU under the baseline.

On the other hand, environmental risks potentially associated with treated wastewater reuse (presented in sections 2.1 and 3.3), such as chemical contaminants from inorganic salts, nutrients, heavy metals and micro pollutants, e.g. detergents would also remain minimal. Emerging pollutants, such as pharmaceutical products and their metabolites, personal care products, household chemicals, food additives, etc., in particular, represent a growing environmental concern. At the moment, however, there is no scientific consensus on the actual level of risks associated with many of these various substances and further research is required[93].

5.2.2 Economic impacts

A wide range of economic impacts associated with reuse schemes under a BAU scenario were identified in the previous impact assessment study by BIO Deloitte (2015). These were built on, including, in particular:

[93] Federal Environment Agency (2016) UBA texts 34/2016: towards a framework for the sustainable use of treated wastewater for agricultural irrigation

- **Price of reclaimed water and cost of reuse solutions**. Water reuse schemes remain relatively underdeveloped in the EU owing among other reasons to a lack of economic attractiveness and perceived low returns on investment. Many existing reuse schemes have benefited from direct or indirect subsidy to support both supply and demand, but this is at odds with the need for cost recovery and financial sustainability in the water sector. Given the existing structure and level of pricing for freshwater, without any policy measures to incentivise / support the financial sustainability of water reuse schemes, water reuse is unlikely to increase without generating supplementary costs for water users;
    - **Pricing for water services** in the EU is defined within Article 9 of the Water Framework Directive and stipulates the principle of cost recovery (including environmental and resource costs) as well as the polluter-pays principle. Evidence available suggests that, at best, only financial costs of water treatment and distribution are included in tariffs: few Member States apply direct charges to polluters for the purification of their wastewater as well as other activities that impact on water quality, and charging for the resource costs of water abstraction is rare (EEA, 2013). Furthermore, in agriculture, low levels of cost recovery (up to 80% but sometimes as low as 20%) point to heavy subsidisation of freshwater use, even in water-scarce Mediterranean countries (EEA, 2013). The persistence of such price signals would dis-incentivise both water efficiency and water reuse by failing to account for the full external costs of freshwater abstraction and wastewater discharge;
- **Avoided costs related to droughts**. Water reuse solutions contribute to reducing the associated costs of economic damages, reducing the constraints on economic development due to water shortages and reducing the economic consequences of uncertainty about water availability – a potential obstacle to investment decisions. In the absence of policy intervention, these costs can be expected to increase substantially in some regions. Recent droughts have undoubtedly resulted in increasing and significant impacts on the economy and on natural resources (BIO, 2015);
- **Benefits for the water reuse industry, EU competitiveness and innovation potential**. There is a rapidly growing world water market, which is estimated to be as large as 1 trillion Euros by 2020. By seizing new and significant market opportunities, Europe can increasingly become a global market leader in water-related innovation and technology (EC, 2012). According to Global Water Intelligence the global market for water reuse is one of the top growing markets, is and on the verge of major expansion and going forward is expected to outpace desalination[94]. The EU water reuse sector is maturing both technologically and commercially, albeit at a slow rate. Given the importance of the water industry sector in the EU, the past and current spread of water reuse technologies in the EU and worldwide has been a driver for the competitiveness of this industry sector, and this situation is expected to continue over the next 10 years. Water supply and management sectors already represent 32% of EU eco-industries' value added and EU companies hold more than 25% of the world market share in water management (EU, 2011) (BIO, 2015);
- **Internal market**. The heterogeneity of national requirements (including the lack of these) concerning the management of health and environmental risks associated with water reuse constitutes a barrier with a potential to affect the **internal trade of agricultural products irrigated with reclaimed water** (BIO, 2015);
- **SMEs and microenterprises**. One of the sectors that is the most directly impacted by current water reuse practices is the agricultural sector, which encompasses a wide number of microenterprises (i.e. farms). Water reuse provides economic benefits to farms, by increasing water availability for irrigation. Under a scenario of increasing scarcity due to climate change, as well as regulatory changes under the WFD, financial costs of securing freshwater supplies are

[94] Global Water Intelligence, 2015, Vol I summary

likely to increase for agricultural businesses, although few agricultural SMEs bear the cost of wastewater treatment directly (BIO, 2015);

- **Administrative burden.** No impact was identified on administrative burden as no change would be made so no reporting or monitoring costs would be relevant;
- **Competiveness and innovation.** The absence of incentives for further water reuse would lead to no impact on competitiveness and innovation related to water reuse technologies and their application to agriculture or aquifer recharge. Considering the potential worth of this market, this could lead to a loss of opportunities for the European market to be a leader on this issue; and
- **ICT**. No impact on ICT was identified as under the baseline scenario there is no requirement for any communication technologies or any integration with existing ICT systems.

5.2.3 Social impacts

BIO (2015) identifies a wide range of social impacts associated with current uptake of water reuse schemes, including, in particular:

- **Public health**. Risks to public health are one of the key concerns associated with the reuse of treated wastewater. These risks may occur through direct or indirect exposure of the public to microbiological agents (pathogens) or chemical substances that are usually present or may be present in treated wastewater. Health impacts of water reuse depend upon the wastewater origin, the conditions imposed in terms of treatment and the subsequent use of the treated wastewater. The composition of reclaimed water may vary depending on the origin of the collected wastewater, season and treatment applied (ANSES, 2012). According to the WHO, for the reuse of water in agriculture, the greatest health risks are associated with crops that are eaten raw (e.g. salad crops), especially root crops (e.g. radish, onion) or crops that grow close to the soil (e.g. lettuce, zucchini (courgette)) (WHO, 2006). To minimise health risks associated with different hazards and exposure levels, ISO 16075 stipulates a multi-barrier and risk assessment approach applicable to treated wastewater reuse in irrigation projects. There are very few health risk quantification studies and epidemiological studies on the reuse of reclaimed water; most of epidemiological results concern the reuse of raw sewage (where the contamination risks are much higher). The literature does not report cases of human diseases caused by treated wastewater in the EU. Some uncertainty, however, remains in relation to any potential long-term effects (e.g. associated with exposure to micro-pollutants);
- **Occupational health**. Different types of workers may be exposed to treated wastewater and to the possible microbiological and chemical contaminants mentioned in the above section: farmers and workers in the reclaimed water industry. While the workers may be exposed to potential contaminants over longer periods than the public, the risks are not necessarily higher due to better awareness and the implementation of risk control measures (e.g. protective equipment). The literature does not report cases of occupational diseases caused by exposure to treated wastewater (BIO, 2015);
- **Employment.** As a means of increasing water availability, water reuse provides further economic security to agricultural producers, which translates into social benefits. This enables jobs to be secured, providing benefits to local communities (EC, 2012) (BIO, 2015);
- **Public acceptance**. The reuse of wastewater raises issues in terms of public acceptance, especially for drinking water production applications. The type of application for which water is reused is an important factor for public acceptance. Public acceptance decreases when public health is at stake or when there is a risk of contact or ingestion of reclaimed water. For instance, public acceptance of reusing water to irrigate crops that are intended to be eaten or to wash clothes can be low while reusing water for bioenergy cropping will not cause serious public concerns (IEEP et al., 2012). Public acceptance is difficult to achieve as long as citizens are not fully aware of the need to reuse treated wastewater to alleviate water scarcity and droughts, associated potential risks and adopted risk management strategies and consider it an efficient solution to address water scarcity and to reserve high quality water supplies for drinking water

purposes. The first stage of acceptance of the use of reclaimed water is the acceptance by the community of the need. In this case, the use of reclaimed water becomes a solution to a problem and this, in turn, is an important driver of public perception (UK Water Research Industry, 2003). According to WSSTP (2013), growing confidence in technologies such as ultrafiltration, reverse osmosis, membrane bioreactors, and ultra-violet disinfection, has also reduced public health concerns about reuse (BIO, 2015); and

- **Governance and participation**. Many developers are aware that stakeholder participation is a key success factor for the development and efficient operation of water reuse schemes. In order to build trust and get support, developers and local authorities therefore need to initiate stakeholder awareness raising actions, consultation and collaboration activities during the development of new water reuse schemes. In most cases, the development of water reuse projects is thus an opportunity to enhance good governance practices and public participation. (BIO, 2015).

Under the baseline (refer to the Section 3) only Spain is expected to increase its water reuse volume to the stated target of 1,200 million m^3/year by 2018. Otherwise only limited increases in the uptake of wastewater reuse are anticipated in other Member States.

5.3 Option Ag.2 Development and promotion of non-binding standards for water reuse for agricultural irrigation

Environmental, economic and social impacts associated with the development and promotion of non-binding standards for water reuse for agricultural irrigation would be strongly affected by the non-binding nature of this instrument and the pre-existence of any national standards governing reuse of treated wastewater for irrigation.

Under this option Member States that do not currently have national standards would have complete freedom on whether to adopt the recommended non-binding standards or not. This decision would depend on a wide range of factors including potential demand for treated wastewater in the country having regard to and the possible extent of water scarcity; the nature of the proposed minimum quality recommendations and associated risk management measures; associated costs of wastewater treatment and supply for irrigation use; as well as any environmental and public health concerns.

Member States that currently do have national wastewater reuse standards will have a choice between retaining their (more or less stringent national standards) and aligning their own standards with the proposed EU-wide recommendations.

Overall, Member States with relatively more stringent national standards are likely to retain these in order to avoid the perception of compromising health and environmental protection adopting somewhat lower standards. However, the option of alignment would still be available to these Member States.

Member States with relatively less stringent national standards are also likely to retain their own standards in place (as demonstrated by the case studies), to avoid: (i) administrative burden; and (ii) additional compliance costs for water reuse companies and farmers. However, similarly to the above, the option of aligning the national standards with the non-binding EU standards would be available to these Member States as well. Adopting the more stringent EU non-binding standards might be seen as a further safety guarantee by water users, and for example they might then be more willing to buy fruit and vegetables including those to be eaten raw irrigated with recycled water thereby promoting the uptake of more stringent standards.

Further consultation with relevant competent authorities and national trade bodies would be required to determine anticipated uptake (in quantitative terms) of the non-binding standards in different Member States.

The development and promotion of non-binding standards for treated wastewater reuse for irrigation would constitute an enabling tool that could assist with development of the treated wastewater reuse framework.

5.3.1 Environmental impacts

Same environmental impacts as under the baseline are anticipated for the Member States with or without national standards that would choose to retain the current status.

Positive impacts on water resources associated with increased uptake of water reuse and water availability would be anticipated in situations where Member States currently without national standards would choose to adopt the EU wide standards and where Member States with more stringent national standards would choose to align these with the EU wide recommendations. While in theory, aligning relatively more stringent national standards with the EU recommended standards is a viable option, it is unlikely to be pursued due to implications for public perceptions in relation to (perceived) lowering of environmental and human health protection ambitions.

On the other hand increased uptake of water reuse might be associated with increased potential for environmental risks associated with introduction of pollutants to soil and water bodies (e.g. in the case of Member States without national standards choosing to adopt the EU wide standards and in the case of Member States with more stringent national standards choosing to reduce the stringency of their standards to align them with the EU wide recommendations). Conversely, increasing the stringency of the national standards to align these with the proposed EU wide recommendations would contribute to reduced risks associated with environmental pollutants present in treated wastewater.

It should be highlighted, that the proposed EU wide standards are adequate to control human health and environmental risks.

Environmental impacts associated with the Member States without national standards adopting the EU wide recommendations and Member States with less stringent standards choosing to align these with the proposed standards would be as follows:

- **Water resources**. Overall, reuse of treated wastewater decreases quantitative pressures on freshwater resources, by giving “a second life” to water. Irrigating crops with recycled water saves freshwater resources that can be diverted to other uses (e.g. domestic) or to the environment. In some Member States, and especially in the Southern regions, seasonal water scarcity often threatens domestic water supply, which is normally given priority over agricultural irrigation. The same can be said for coastal areas during the seasonal tourism peak; in addition, it must be noted that the peak is usually in summer, which is the driest season of the year. Water reuse during this period would reduce the need for freshwater abstraction and release pressures on domestic water supply. The amount of treated wastewater used for irrigation in aggregate terms is not anticipated to increase significantly as a result of adoption of this option as most of the Member States with a strong demand for the practice already have developed national standards. For Member States without national standards adoption of this option would result in increased volumes of water being reused (albeit marginal as Member States with a strong national demand for treated wastewater reuse could have already developed national standards). It should be noted, however, that diversion of treated wastewater from being discharged to the environment to reuse might adversely affect flows in affected water bodies. In Member States with existing national legislation (e.g. France) this policy option would not promote an expansion of water reuse practices in the country; if anything, aligning the national standards with the EU wide recommendations where these are relatively more stringent could reduce the levels of current uptake if additional treatment would be required at prohibitive costs;
- **Water quality:** On one hand, opting for water reuse could contribute to improved quality of freshwater resources as a result of further reduction in wastewater discharge on sensitive rivers and reduced risk of saline intrusion in over-exploited coastal aquifers. On the other hand, increased uptake of treated wastewater reuse in agricultural irrigation would need to ensure adequate controls of potential environmental risks including managing chemical contaminants, nutrients, heavy metals and micro pollutants that can negatively affect the environment. For heavy metals there are concerns that these substances can build-up in the soil over time. Salinity of the water is also a risk to the environment and to crops. While using treated water containing nutrients for irrigation can constitute an environmental benefit whereby the nutrients are used by the crop rather than being discharged into water bodies, careful management is

needed to ensure minimised risks of nutrient run-off and increased eutrophication. Finally, there are also growing concerns over the fate of the wide variety of emerging contaminants (e.g. pharmaceuticals, CECs), which are present in sewage, often at trace levels, and which are often unmonitored. Evidence remains limited as to how well treatment processes deal with these pollutants:

- For Member States without national standards adoption of the EU wide recommendations could result in increased volumes of water reused (albeit marginal as Member States with a strong national demand for treated wastewater reuse could have already developed national standards) leading to increased potential for environmental risks associated with introduction of pollutants to soil and water bodies. However, at the same time, this could also contribute to improved quality of freshwater resources as a result of avoided wastewater discharge to surface water bodies or soil and introduction of additional treatment that would be required to comply with the minimum water quality recommendations; and
- Conversely for Member States with less stringent standards choosing to align these with the proposed standards, this would promote and strengthen the level of current safeguards and protection of soils and aquatic environment.

- The **impact on soil** would depend on the quality parameters considered in the recommendations: while the presence of some nutrients and organic matter in treated wastewater can be beneficial to enhance soil fertility and crop production, the presence of other elements (e.g. salts, micro pollutants) may be detrimental, as well as impacting on the wider environment. Impacts would also depend on the properties of soil at any given location;
- **Renewable and non-renewable resources (energy)**. Water reuse may result in more efficient energy use in the water supply and wastewater treatment sector in those Member States adopting the standards. Several reports and studies have looked into comparing use of energy from water reuse and other alternative sources such as desalination, in particular in Californian literature, where both options are often considered. On average, a water treatment plant uses 2,500 kWh per million gallons of water treated[95]. The energy use varies based on the characteristics of the water being treated, the distance and elevation of the treatment plant and the distribution system. In comparison, desalination of sea water (in particular processes based on thermal distillation or membrane filtration technologies which are energy intensive) requires from 9,780-16,500 kWh/ million gallons). Further comparisons are presented in the table below.

Table 5.2 Overview of energy use per water source in California

Type of water source	Average energy use in kWh per MG
Waste water treatment plant	2,500
Seawater desalination	9,786-16,500
Groundwater desalination	3,900-9,750

Source: California's Water-Energy Relationship

- In addition, in general terms, use of treated wastewater for irrigation would require an equivalent or increased level of wastewater treatment. It is unlikely that the treatment level could be decreased below the level of purification/treatment necessary for discharge under the UWWD. This would result in equivalent or increased energy consumption and costs associated with water treatment. In particular, different treatment technologies allow different levels of water quality to be achieved, with technologies such as dual membrane tertiary treatment processes that combine micro-filtration and reverse osmosis allowing the highest quality of treated water to

[95] California's Water-Energy Relationship, 2005, http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF

be achieved. Such treatment processes, however, are energy intensive. However, whilst there would be additional energy use, this would to some degree be offset by avoided energy consumption associated with freshwater abstraction, treatment and distribution. In particular, reusing treated wastewater (as opposed to discharging it and abstracting and treating freshwater anew) can result in net energy savings. However, it should be noted that the net energy savings or increases will depend on the current levels of treatment and particularities of water supply, and the extent of increases in wastewater treatment where applicable.

5.3.2 Economic impacts

Same economic impacts as under the baseline are anticipated for those Member States either with or without national standards that would choose to retain the current status (including those Member States with more stringent national requirements).

In general terms adoption of the new EU wide standards (by the Member States without national standards) or alignment of the national standards with more stringent EU wide recommendations would on one hand result in additional costs to water industry operators and farmers (associated with increased costs of wastewater treatment, storage and distribution if more advanced processes and additional infrastructure is needed as well as administrative burden costs). On the other hand, adopting the EU wide recommended standards or aligning the national standards would contribute towards reduction of heterogeneity among Member States and would promote removal of possible trade barriers for agricultural products irrigated with treated wastewater.

Economic impacts for those Member States without national standards adopting the EU wide recommended standards and Member States with less stringent standards choosing to align these with the proposed standards for water reuse in agricultural irrigation would be as follows:

- **Operating costs (farmers)**. For the Member States without existing standards, those with less stringent national legislation and those monitoring others parameters (e.g. COD instead of BOD) existing wastewater treatment plants might need to upgrade their treatment processes in order to achieve the recommended EU wide standards including for selected parameters that are relatively more stringent (TSS, E. Coli and COD[96]) resulting in additional costs. However, these costs would be offset to some degree by a reduction in the current costs of irrigation water supply (if any). The aggregate magnitude of additional costs is unknown at present and will depend on technologies currently in use at specific wastewater treatment plants. To illustrate the potential cost impact of upgrading a wastewater treatment plant from biological treatment to advanced tertiary treatment investment costs can be considered. In particular, installation of nanofiltration followed by reverse osmosis treatment would be associated with investment costs of around 10 million Euro (for a WWTP treating up to 10,000 m^3 per day). Depending on the price of treated wastewater, adoption of such an instrument might have a limited applicability in some Member States (e.g. Romania) where farmers are currently often unable to afford irrigation at current water prices. The increased prices associated with treated wastewater reuse that can be reasonably expected would act as a deterrent to widespread uptake of the recommended standards. It should also be noted that products irrigated with treated wastewater might become more expensive, due to increased costs of production as a result of additional investment in more advanced treatment processes;
- **Water suppliers**. If EU wide standards were to be adopted in Member States without national standards and in Member States with relatively less stringent national standards, operators could face additional investments in wastewater treatment, storage and distribution and increased sampling costs in order to comply with the recommendations while dealing with uncertain demand for the treated wastewater from the farmers;
- **Functioning of internal market and competition**. For, Member States with existing national standards that are less stringent in some respects (e.g. particular parameters) that choose to

[96] Due to restrictions under REACH on the use of potassium dichromate as the measurement method there are ongoing discussions at the EU level about the use of COD under the UWWD. Any parameters proposed in relation to reuse would need to take account of the conclusions of those discussions.

align their national standards with the proposed EU standards, positive impacts on the internal market and competition would be expected. Similarly, for those Member States without national legislation, the adoption of the EU wide standards would result in a positive impact on competition and trade through reduced differences in the standards used in different Member States. This is the area where most positive impacts are expected. Promoting a similar approach for all EU Member States would contribute towards a more informed and safe consumer choice, with positive impacts for the internal market. The impacts on competition with imports from third parties are expected to be neutral. Negative impacts could be expected were the price of agricultural production increase as a result of water reuse. If this were the case, it is expected that farmers would not opt for water reuse in the first place. The impacts on products exported from the EU to other countries are expected to be neutral. There was no identified restriction on export / import from agricultural products based on irrigation method;

- **Administrative burdens on businesses (water operators and farmers)**. A comparison of the existing quality standards and those proposed by JRC (Appendix A, draft from March 2016) showed that some are less and some more stringent than those in Member States with national standards for water reuse. For example, for France there are three more stringent parameters that, should France elect to apply the recommended EU standards, would require existing WWTPs to submit an application to amend their permits. If the Member States with relatively less stringent standards were to adopt the proposed EU wide standards, then this would place a burden on businesses to update their permits accordingly. Similarly, for Member States with no national legislation, the adoption of the EU wide standards would lead to some burden on businesses to be permitted / registered as required;
- **Economic impacts for public authorities**. For those Member States with existing national standards that might adopt the EU wide standards, their current systems (quality categories, quality parameters) would not change in terms of conceptual design, so upgrading the limits on some parameters would not require significant administrative adjustments. However for those Member States with no national legislation, the burden on public authorities would be important, in terms of setting up the administrative system to allow water reuse for agricultural irrigation;
- **SMEs and microenterprises**. Impacts on SMEs are expected to vary. Some impacts will be positive as they would benefit from an increased and/or better secured access to water. Agricultural businesses, which are the largest consumer of freshwater in Member States, would benefit from more access to water resources. This may in turn encourage an increase of agriculture in some Member States currently restricted by water availability. However, initial investments to set up irrigation infrastructure may be an important cost. Furthermore, the complexity of the current legislation in some Member States is seen as limiting the uptake of water reuse. Compliance with new (for Member States without national standards) or more stringent limits for some of the quality parameters, would introduce additional constraints to the development of wastewater reuse for irrigation purposes. This, in turn, may impact farmers, most of which are SMEs. However, these constraints are unlikely to materialise in circumstances where costs of uptake would be prohibitive:
    - It should be highlighted, that in Greece, a water balance analysis has revealed that over 83% of the discharged WWTP effluent is produced in regions with a water deficit. Furthermore, over 88% of the effluents from WWTPs are discharged within 5km of available farmland, which implies that the additional cost for wastewater reuse in irrigation could possibly be technically and economically affordable. For example, the WWTP of Psyttaleia, which serves the broader capital area of Attica (35% of the Greek population) could possibly contribute 20,000 m3/day of treated effluent for landscape irrigation at an estimated cost of 0.40 €/m3. This cost can be contrasted with the average price of water for irrigation that ranges between 0.02-0.70 €/m3 in case of volumetric billing. However, in the case of self-abstraction, the estimated costs of groundwater pumping range from 0.02-0.03 €/m3 (Appendix D, case study for Greece).
- **Consumers and households**. The trade of agricultural goods irrigated with reclaimed water would be positively influenced which could benefit consumers. However, additional costs for water reclamation plants might imply increase costs to water users including farmers, and

hence to consumers. However, an increase in irrigation water prices might provide a negative incentive to the use of recycled water in irrigation. Alternatively, as often happens, additional costs might be recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with the available data and information;

- **Innovation and research**. The introduction of standards might promote research on innovative treatment technologies. For example, in the UK Water Industry Research recently concluded a project entitled 'Establishing a Robust Case for Water Reuse'[97] which showed that reuse is a technically viable water source in a range of applications, geographies, and scales. Considering that water reuse is an emerging worldwide market, a greater uptake of reuse at the EU level would provide a showcase for the relevance of these technologies and skills of EU companies towards potential customers in third countries. Impacts on competitiveness and innovation are expected to be positive as removal of current barriers to investment is anticipated[98]. A clear and consistent EU framework would allow economies of scale and standardisation. This in turn would support innovation and development of solutions at lower costs; and
- **ICT**. Reporting under the policy option would most likely entail the use of existing reporting stream such as the reporting under the UWWTD in WISE. If included, separate guidance could be provided in order to define the content and format of information to be reported. There would be minimal burden in adding further reporting fields at the European level. At national level, reporting would be parallel to compliance monitoring performed by the competent authorities and would also lead to minimal additional burden.

5.3.3 Social impacts

Same social impacts are anticipated as under the baseline for the Member States without national standards that would choose to retain the current status. In any instance, where Member States with more stringent national requirements would choose to align with the EU standards, i.e. lower, their national standards, some adverse impacts in terms of compromised public acceptance could be anticipated.

Conversely, adoption of the new EU wide standards (by the Member States without national standards) or alignment of less stringent national standards with more stringent EU wide recommendations would positively impact on promotion of public acceptance.

Social impacts associated with the Member States without national standards adopting the EU wide recommendations and Member States with less stringent standards choosing to align these with the proposed standards for water reuse in agriculture irrigation would include:

- **Public and occupational health**. In those Member States with national legislation, this option is expected to bring little additional benefits with regards to public and occupational health with the exception of Member States with less stringent national standards choosing to align these with the proposed EU wide recommendations. For Member States with no legislation but which opt to adopt the recommended minimum water quality standards, this would provide a framework for protection of human health and safety of individuals/populations. The option would also decrease the likelihood of health risks due to exposure to dangerous substances;
- **Employment and labour markets**. The establishment of an EU framework together with improved communication on actual risks and benefits of water reuse is expected to have a positive impact on confidence of the general public in the quality of the reused water and, therefore, on acceptance of water reuse as a water management tool. More jobs would be created in the water and agri-food industry as well as in innovation and research sectors. Other sectors are expected to be influenced indirectly. For instance, in Greece, data available

[97] http://ukwir.forefront-library.com/report/94658/Reports/90179/Water-Resources/90193/Water-Reuse/97338/Establishing-a-Robust-Case-for-Final-Effluent-Reuse---An-Evidence-Base
[98] It should be noted, however, that innovation and economically viable changes would also take place without adoption of a new regulation.

suggests that investments in wastewater reuse have a growth and employment multiplier of 3.5[99] providing a positive contribution for employment;

- **Governance and legislation**. In Member States where no legal framework currently exists governing wastewater reuse for agricultural irrigation the opportunity to fill the existing gap in the national legal system by adopting these EU wide standards is present; and
- **Public acceptance**. Adoption of the EU wide minimum water quality recommendations as well aligning less stringent national requirements with the proposed EU wide standards would contribute to consumer protection by ensuring appropriate quality of treated wastewater used for irrigation and hence of agricultural products on the market. An EU action would also bring more confidence to the public on the safety of the practice having a positive impact on the public perception of using recycled water for irrigation.

5.3.4 Impacts identified in case studies

Based on the case studies conducted, adoption of the non-binding standards for agricultural irrigation is likely to result in Member States with existing national standards retaining their national standards or adopting marginal changes. Member States that do not currently have national standards for treated wastewater reuse for agricultural irrigation will be free to develop their national standards, adopt the proposed non-binding standards or refrain from using treated wastewater for irrigation if they choose to do so. On the other hand, while offering significant flexibility to Member States, this option is unlikely to contribute significantly towards the goal of promoting increased uptake of treated wastewater reuse across the EU.

In **Cyprus**, the use of treated wastewater for irrigation (of orchards, fodder crops, landscapes etc.) is an important factor in mitigating the impacts of agriculture on groundwater. The Cypriot standards are generally stricter than the proposed minimum quality recommendations stipulated in Appendix A. Furthermore, the Cypriot standards are simpler, as they contain fewer categories and reference tables. Therefore, Cyprus would be expected to keep its own legal framework. In terms of the impacts, these would be similar to the baseline, including the costs of wastewater treatment, distribution and monitoring. However, development and promotion of non-binding standards at the EU level is expected to positively affect public acceptance, albeit to a limited degree, through providing further reassurance to farmers about the safety of such a use (Appendix D, case study for Cyprus).

Similarly, in **Italy**, standards under national legislation are stricter than those presented in Appendix A, so it is likely that the Italian regulation would not change in the presence of non-binding standards for water reuse at the EU level. For this reason, no impact can be expected from the introduction of such standards (Appendix D, case study for Italy).

In **Spain,** Royal Decree 1620/2007 establishes thresholds for reuse of treated wastewater in agricultural irrigation that are more stringent than what is being considered at EU level, both in terms of quality criteria (maximum acceptable values; presence/absence of certain parameters according to type of water use) and risk management measures resulting in no change to the national standards following the adoption on non-legally binding recommendations (Appendix D, case study for Spain).

In **Greece**, the existing standards differ significantly in concept from the standards included in the draft proposal considered. Since the recommended EU instrument is not mandatory, it is expected that the Greek authorities would not adopt make changes (Appendix D, case study for Greece). At best few marginal changes, such as adding some new analytical parameters may be considered if deemed appropriate. For instance, adding tetracycline or cefotaxime resistant E. Coli and Boron in the Greek standards would have a low impact on the total cost for monitoring and it is not expected to cause any change in the level and cost of effluent treatment (Appendix D, case study for Greece).

France already has well developed regulations on water reuse for irrigation purposes and is not anticipated to change relatively more stringent elements of the national standards, e.g. parameters to be monitored. On the other hand, alignment of the less stringent thresholds (for the parameters shared with the proposed EU

99 Appendix D, Processed data by the authors

approach such as TSS, E. Coli and COD)) would result in introducing more stringent numerical thresholds for these parameters (Appendix D, case study for France).

In **the UK** a number of initiatives associated with water reuse have already been introduced by water companies and the Environment Agency despite the absence of national wastewater reuse standards. These initiatives included, among others, a position statement by the EA on effluent re-use for potable water supply[100] that highlighted that treated effluent is an important, reliable and valuable resource; and a strategy adopted by the public water utility company for London (Thames Water) that has forecasted a deficit of 150 million litres per day by 2025[101]. A high profile wastewater reuse project was the water reuse scheme of the London Olympic Park (for toilet flushing and irrigation use) achieving a 57% reduction in the use of potable water against the set objective of 40%[102] of which water reuse accounted for 37%[103]. Development and promotion of legally non-binding standards for water reuse at the EU level would provide a reference point to the UK and promote the discussion on introducing water reuse standards for agricultural irrigation at the national level.

The summary of the anticipated environmental, economic and social impacts in selected Member States is presented in Appendix D (see Appendices C and D for the approach to the selection and the case studies).

5.4 Option Ag.3. Development of legally binding standards for water reuse for agricultural irrigation

This policy option would introduce a legally binding instrument (e.g. a Regulation or Directive) setting out quantifiable minimum water quality requirements that must be complied with when using treated wastewater in agricultural irrigation. The option would include specifying risk management measures that must be complied with, alongside water quality parameters.

Environmental, economic and social impacts associated with development and promotion of legally binding minimum standards for water reuse for agricultural irrigation will depend on the pre-existence of any national standards governing reuse of treated wastewater for irrigation and their relative stringency vis-à-vis the proposed requirements. Ultimately, development of legally binding minimum water quality requirements is aimed at increasing uptake rates of treated wastewater reuse for agricultural irrigation.

Farmers and water industry operators in the Member States that do not currently have national standards and that do not employ treated wastewater reuse would still retain freedom as to whether or not to adopt the treated wastewater reuse requirements or not. This decision will depend on a wide range of factors including potential demand for treated wastewater in the country for this particular use, associated costs of treatment and supply and public health concerns. Determining potential uptake (in quantitative terms) would require further consultation with Member State authorities and relevant trade bodies on the final version of the proposed EU-wide standards, once these are available.

However, in comparison to the non-binding standards (Ag2) this option would ensure overall coherence across the EU in relation to minimum quality requirements as and when actors within individual Member States choose to adopt the practice of wastewater reuse.

Overall, Member States with relatively more stringent national standards are likely to retain these in order to avoid compromising public perception and acceptance by adopting lower (while still sufficiently protective) standards. However, the option of aligning national standards would be available to these Member States and entail additional administrative costs. These are explicitely considered in the descriptions of the case studies below.

Anticipated environmental, economic and social impacts under this option would be similar in nature to those associated with the Ag2 policy option. The key difference is associated with anticipated scale of uptake based on the fact that a binding document would send a stronger message of support than a non-binding

[100] Environment Agency, Position statement, Effluent re-use for potable water supply, June 2011
[101] Water reuse in Europe moves forward, World Water Journal, Spring 2016 Vol 7 / Issue 1
[102] Lessons learned from the London 2012 Games construction project:
http://learninglegacy.independent.gov.uk/documents/pdfs/sustainability/3-water-strategy-sust.pdf
[103] Water efficient fittings achieved 18% and rainwater harvesting systems and backwash recycling on the swimming pools accounted for the remaining 2%

document. However, as both consider minimum requirements, the scale of differences remains limited (as reflected in the summary table).

5.4.1 Impacts identified in case studies

The summary of the anticipated environmental, economic and social impacts in selected Member States is presented in Appendix D.

Farmers and water industry operators in different Member States would face the same choices as under the option Ag2.

Based on the case studies conducted three main situations were identified:

1. Member States with no legal framework for water reuse.

In, for example, **Romania**, while the current legal framework allows the reuse of treated wastewater, it does not have specific standards and regulations referring to irrigation that would facilitate large scale implementation. Farmers and water operators in Romania, therefore, would have freedom to choose whether to adopt the legally binding standards for treated wastewater reuse in agricultural irrigation or to continue with the present situation, i.e. not to implement the practice at all. From a practical point of view, adoption of legally binding minimum requirements in the Romanian context would require the combined work of different authorities at governmental level (agriculture, environment, health), standardisation organisations, with input from associations of farmers that are connected (or intend to connect) to the irrigation system, water operators and other public agencies. It would result in more monitoring requirements for treated effluent discharges in comparison to the current legislation that requires fewer parameters to be monitored (e.g. under UWWD) than stipulated in Appendix D, case study for Romania.

2. Member States where national standards for the reuse of treated wastewater for agricultural irrigation do exist, but these are less stringent than proposed EU standards. These Member States will be required to fully or partially adjust the national standards to align them with legally binding minimum requirements.

For instance, **France** is one of the countries where the proposed minim water quality requirements presented in Appendix A seem more restrictive than the existing national standards. However, as far as bacteriological parameters are concerned, the French regulation imposes further restrictions that are not included in the proposal. Nevertheless, both French regulations and the EU proposed minimum requirements are based on the same quality categories, which means that the French regulation could be adjusted to the proposed EU regulation by changing the numerical values of parameters. More specifically, in the case of **France**, the adoption of the proposed EU standards would result in:

- adopting more stringent thresholds for E. Coli and TSS;
- introducing BOD among the parameters (possibly in substitution of the COD parameter); and
- introducing the turbidity parameter (Appendix D, case study for France).

It is assumed that the existing microbial parameters would continue to be included in the French regulation (Appendix D, case study for France).

Alignment of the existing national regulations with an EU set of standards such as those presented in Appendix A could result in increased costs of wastewater treatment e.g. to ensure compliance with the relatively more stringent E.Coli and TSS parameters. This, however, will depend on the treatment technologies currently employed at the wastewater treatment plants affected. It should be noted that, due to good hydraulic infrastructure and sufficient rainfall around the country, treated wastewater reuse for irrigation is limited to particular regions, such as islands or areas with a high water demand and uses possibly conflicting with potable use. (Appendix D, case study for France).

3. Member States whose national standards are more stringent than the proposed EU wide minimum quality requirement could choose to either retain their relatively more stringent national standards or to fully or partially adopt the proposed minimum requirements (implying a relaxation of existing requirements).

In particular, for these Member States, less stringent water quality requirements (if adopted) would result in equivalent or marginally reduced treatment costs (where technically feasible[104]). However the highest share of the total cost associated with water reuse is due to infrastructure such as treatment, storage and distribution; thus the reduction in current costs would be limited. No additional costs are anticipated in instances where these Member States would continue using their existing more stringent national standards.

Spain could be an example of the first option (retain national standards). Royal Decree 1620/2007 establishes thresholds that are more stringent than those being considered at EU level, both in terms of quality criteria (maximum acceptable values; presence/absence of certain parameters according to type of water use) and risk management measures, for reuse of treated wastewater in agricultural irrigation. No additional changes to the national system are envisaged (Appendix D, case study for Spain).

Greece, would be likely to be an example of the second option (i.e. aligning the national standards with the proposed EU wide minimum water quality requirements. Greek standards for food crops to be eaten raw already require secondary treatment, advanced treatment and disinfection and the minimum threshold values for all monitored parameters are much stricter than those stipulated in Appendix A. Greek standards for non-food crops also require secondary treatment and disinfection and the minimum threshold values are more stringent than those presented in Appendix A, which do not require disinfection for this category (Appendix D, case study for Greece). Therefore, adopting the standards considered in Appendix A (and lessening the national standards in places) would result in reduced treatment costs, as the Greek standards are overall much stricter in relation to wastewater treatment. Currently wastewater reuse seems to be more expensive than other freshwater sources. Therefore, reduced costs for treatment are expected to improve its competitiveness. However, existing data from case studies suggest that the cost of upgrading the WWTP (i.e. additional treatment) represents only a low share of the total cost (around 5%). The major costs in wastewater reuse come from associated infrastructure (e.g. pipes, tanks, irrigation systems) (Appendix D, case study for Greece).

Italy is another country where national standards for treated wastewater reuse are more stringent than those stipulated under the standards presented in Appendix A (with the exception of BOD) (Appendix D, case study for Italy). A feasibility study for a reuse scheme in Northern Italy conducted a cost benefit analysis of water reuse for agriculture. The benefits from reducing the impact of droughts on agriculture were estimated to be more than €1 million per year. There were also environmental benefits estimated at of €5.3 million based on the improvement of the quality of the water of the canal currently receiving the effluent. The conclusion of the CBA was that, despite important investment costs, the switch to reuse was financially sound with a payback period of 20 years[105].

In particular, the stringency of existing national requirements has led to some difficulties in promoting wastewater reuse due to the need for advanced and costly wastewater treatment processes. Furthermore, the number of parameters to be monitored exceeds 50 and the sampling frequency can be very high, resulting in significant costs. Under these conditions, the total cost of treatment plants (construction, operation and maintenance), distribution and monitoring are likely to be feasible for large WWTPs only, thereby, reducing the benefit of wastewater reuse and hampering the development of such practices in smaller WWTPs. Average costs of wastewater treatment range between 0.083 and 0.48 EUR/m^3. As a comparison, the costs of abstracting water from rivers and groundwater bodies is estimated at 0.015-0.2 EUR/m^3. The high cost of treated wastewater is generally indicated as one of the main barriers to water reuse (BIO, 2015). With water availability differing significantly between Northern Italy (stable and abundant flows in water courses throughout the year) and Southern Italy (often subject to long periods without precipitation, resulting in droughts and water rationing), wastewater reuse is likely to constitute an appealing option in areas where the costs of abstracting freshwater are already very high (for geographical and climatic reasons) and against which water reuse becomes convenient and competitive (Appendix D, case study for Italy). The introduction of the standards considered in the study to support Commission's impact assessment is likely to reduce the costs of adapting current wastewater treatment plants to water reuse practices and

[104] Any such instances of reduced levels of wastewater treatment (where relevant) would need to ensure that no deterioration is taking place in surface and groundwater quality and no adverse impacts occur in aquatic environment. Particular attention would be required to safeguard the state of drinking water sources.

[105] Verlicchi P, et al A project of reuse of reclaimed wastewater in the Po Valley, Italy: Polishing sequence and cost benefit analysis, Journal of Hydrology, 432-433 (2012) 127-136

promote a wider adoption of water reuse technologies (in case Italy were to relax the existing national standards to match the proposed minimum water quality requirements) (Appendix D, case study for Italy).

In the case of **Cyprus**, despite the Cypriot standards being generally more stringent than those presented in Appendix A, the adoption of the EU wide minimum requirements is anticipated to affect the uptake of wastewater reuse positively (see case study). Since the proposed minimum quality requirements are less stringent than current national standards this could result in a decreased level of treatment required and, subsequently, lower energy consumption and wastewater treatment costs (where technically and economically feasible) (Appendix D, case study for Cyprus). On the other hand, changing the existing national frameworks to fit the proposed requirements may entail adoption of a different conceptual framework. In the case of Cyprus such an exercise is likely to result in additional administrative burden. It is, however, highlighted that the increased consistency across the EU is expected to result in a reduction of the administrative burden overall (Appendix D, case study for Cyprus). In the context of SMEs, a positive impact is anticipated as agricultural businesses would benefit from an increased and/or better secured access to water (Appendix D, case study for Cyprus). Finally, considering that water reuse is an emerging worldwide market, a greater uptake of treated wastewater reuse at the EU level would provide a showcase for the relevance of these technologies and skills of EU companies towards potential customers in third countries. The trade of agricultural goods irrigated with reclaimed water would be positively influenced (Appendix D, case study for Cyprus).

5.5 Option Aq.2. Development and promotion of non-binding standards for water reuse for aquifer recharge

This policy option would introduce a non-legally binding document (e.g. Guidance or Recommendations) stipulating minimum quality recommendations for using treated wastewater for aquifer recharge. Specified water quality standards would be determined based on the end-use, i.e. whether the aquifer is used as a source of potable water or non-potable water, as different end-uses require different levels of protection (with environmental compliance standards as a minimum in order to ensure that the standards proposed do not compromise the objectives and requirements of GWD, WFD and DWD). The proposed non-mandatory Guidance or Recommendation also would stipulate sources of wastewater (such as treated urban wastewater) that would be applicable to reuse, and a range of risk management measures.

Environmental, economic and social impacts associated with development and promotion of non-binding standards for water reuse for aquifer recharge would be strongly affected by the legally non-binding nature of this instrument and by pre-existence of any national standards governing reuse of treated wastewater for aquifer recharge and their relative stringency in comparison to the proposed recommendations.

Under this option Member States that do not currently have national standards would have complete freedom as to whether to adopt the non-binding standards or not. This decision would depend on a wide range of factors including potential demand for treated wastewater in the country having regard to the presence and extent of water scarcity; the nature of the recommended minimum quality requirements and associated risk management measures; associated costs of wastewater treatment; as well as any environmental and public health concerns. Determining potential uptake (in quantitative terms) would require further consultation with Member State authorities and relevant trade bodies on the final version of the standards, once these have been fully developed.

Overall adoption of the non-binding standards for aquifer recharge is likely to result in Member States with existing national standards retaining their national standards or adopting marginal changes depending on the position of affected Member State authorities (see case studies).

More specifically, Member States that currently do have national wastewater reuse standards will have a choice between retaining their (more or less stringent national standards) and aligning their standards with the proposed EU-wide recommendations. Overall, Member States with relatively more stringent national standards are likely to retain these in order to avoid the perception of compromising health and environmental protection by adopting somewhat lower standards. However, the option of aligning the national standards would still be available to these Member States. Member States that do not currently have national standards for aquifer recharge would have freedom as to whether to adopt the non-binding standards or not. This decision would depend on a wide range of factors including potential demand for treated wastewater in the country, associated costs of treatment and supply and public health concerns. In practice, having regard to the non-binding nature of this policy option and aquifer recharge using treated wastewater being a prohibited practice in a number of Member States, negligible uptake would be anticipated.

5.5.1 Environmental impacts

No environmental impacts are anticipated over and above those under the baseline for the Member States with or without national standards that would choose to retain the current status (particularly having regard the widespread lack of support for the aquifer recharge practice across the EU using treated wastewater).

Positive impacts on water resources associated with increased uptake of water reuse and water availability would be anticipated in situations where Member States currently without national standards would choose to adopt the EU wide standards and when Member States with more stringent national standards would choose to align these with the EU wide recommendations. While in theory, aligning relatively more stringent national standards with the EU recommended standards is a viable option, it is unlikely to be pursued due to implications for public perceptions in relation to (perceived) lowering of environmental and human health protection ambitions.

On the other hand increased uptake of water reuse might be associated with increased potential for environmental risks associated with introduction of pollutants to groundwater aquifers particularly those used for drinking water abstraction (e.g. in the case of Member States without national standards choosing to adopt the EU wide standards and Member States with more stringent national standards choosing to align these with the EU wide recommendations). Conversely, increasing the stringency of existing national standards to align these with the proposed EU wide recommendations would contribute to reduced risks associated with environmental pollutants present in treated wastewater (where applicable).

It should, however, be highlighted, that the proposed EU wide standards are assumed to be adequate to control human health and environmental risks.

Environmental impacts associated with the Member States without national standards adopting the EU wide recommendations and Member States with less stringent standards choosing to align these with the proposed standards would be as follows:

- **Water quality and resources**. This option is expected to promote research and pilot testing of aquifer recharge. This could lead to some quantitative improvements to the status of groundwater bodies. In particular, in Member States where water reuse is not practiced widely, the uptake of aquifer recharge with treated effluents techniques can significantly contribute to current qualitative and overexploitation issues affecting groundwater bodies; this is especially true in certain Southern Member States. For other Member States, such as France the option is mainly expected to renew discussions in the country (rather than stimulate aquifer recharge). From a quantitative point of view, the practice is unlikely to be widely adopted in some Member States such as Romania where ground water availability is not really a concern. However, the adoption of this practice in groundwater bodies with moderate quantitative status might positively contribute to improving water resources. In any circumstances, promotion of water reuse would need to be carried out in a safe manner addressing and controlling potential risks for the environment through stipulated risk management measures, and through the range of quality parameters stipulated and their stringency;

- **Renewable or non-renewable resources (energy)**. This option would not significantly affect renewable or non-renewable resources, except that more energy intensive, advanced wastewater treatment would be required in some cases; and

- **Environmental consequences for operators**. There are limited impacts from this option on aquifer recharge scheme operators, e.g. water companies. It may in some instance lead to more sustainable groundwater use.

5.5.2 Economic impacts

No economic impacts are anticipated over and above those under the baseline for those Member States with either or without national standards that would choose to retain the current status (including those Member States with more stringent national requirements).

In general terms adoption of the new EU wide standards (by the Member States without national standards) or alignment of the national standards with more stringent EU wide recommendations would on one hand result in additional costs to industry operators (associated with increased costs of wastewater treatment and recharge (if more advanced processes and additional infrastructure is needed) and administrative burden costs).

Economic impacts for those Member States without national standards adopting the EU wide recommendations and for Member States with less stringent standards choosing to align these with the proposed standards for water reuse in aquifer recharge would be as follows:

- **Functioning of the internal market**. No impact on the internal market has been identified;
- **Operating costs**. At present, aquifer recharge with treated effluents does not exist in many Member States that have national treated wastewater reuse standards (e.g. France, Italy and Romania). The introduction of this practice would involve significant investments for those entities wanting to engage in this practice potentially affecting public authorities (e.g. regional authorities, in charge of water management) who would invest in this practice and /or existing water treatment/recycling companies (e.g. those currently practicing water recycling for irrigation). There would likely to be a need to invest in additional treatment technologies, as quality recommendations for treated wastewater for aquifer recharge are expected to be very stringent (effectively using Drinking water quality requirements as a benchmark). Additional transaction and compliance costs can be expected in those situations where aquifer recharge practice already exists, and a new regulation imposes for example stricter standards, or more complex permitting/control procedures. Finally, the operators of the aquifer recharge schemes would also bear the costs associated with risk assessment and management plans and continuous water quality monitoring costs. However, having regard to the lack of widespread support to the aquifer recharge practice using treated wastewater across the EU Member States no significant uptake (and associated costs) would be anticipated. Overall, adoption and application of the EU wide standards could increase the costs to water suppliers, since wastewater would need to be additionally treated to ensure the required quality. This would involve further investments, costs of sampling and testing. In some Member States (e.g. Italy) this option could promote aquifer recharge with treated effluent at the experimental level (see case studies). It can be expected that research and pilot testing would be conducted by public institutions with the participation of private institutions financed by public funding (e.g. LIFE, Horizon 2020 funding as is happening today, as well as national funds). So no relevant impact can be expected on operating costs and conduct of private businesses. However, it is expected to bring about new research and funding opportunities;
- **SMEs and microenterprises**. This option is not likely to impact SMEs disproportionately. Considering that this option is likely to facilitate the investigation of water reuse for aquifer recharge no relevant impact can be expected on operating costs and conduct of private businesses. However, it is expected to bring about new research and funding opportunities. In some Member States a positive impact could be anticipated for non-potable uses such as agricultural irrigation, where there would be a benefit from an increased and/or better secured access to water (abstraction);
- **Administrative burden on businesses**. In general terms, establishing new aquifer recharge schemes would entail permitting/ licensing and monitoring activities to demonstrate compliance with the proposed minimum quality standards and associated costs including developing any background, i.e. hydrological studies. This would act as a burden on suppliers of treated wastewater. Having regard to lack of a widespread support to the practice across the EU no significant uptake (and associated administrative burdens) would be anticipated. Similarly, when conducted at pilot testing level, the additional burden will be limited;

- **Administrative burden on public authorities**. If this option were to be adopted, the administrative burden for the competent authorities would increase slightly (see case studies) due to associated permitting, monitoring and enforcement activities (e.g. monitoring compliance with the minimum quality standards). Public authorities can decide to invest in research and pilot projects, but this would be a voluntary budget allocation decision (potentially compensated by the benefits of new knowledge) and cannot be considered as a negative impact;
- **Innovation and research**. Adoption of a clear and consistent EU framework would positively impact competitiveness and innovation removing some of the current barriers to investments in wastewater reuse technologies. Economies of scale and standardisation opportunities, in turn, would support innovation and development of solutions at lower costs. This option is expected to promote research and innovation in aquifer recharge[106] with treated effluents for Member States that would like to explore this option. However, some Member States have limited interest in this technique;
- **Consumers and households**. Issues related to the quality of water might be of concern for consumers, however this option is not expected to lead to significant impacts; and
- **ICT**. Reporting on the instrument could use existing reporting streams such as the reporting under the UWWTD in WISE. Specific guidance could be adopted in order to define the content and format of information to be reported. There would be minimal burden in adding further reporting fields at the European level. At national level, reporting would be parallel to compliance monitoring performed by the competent authorities and would also lead to minimal additional burden. Reporting would only be required for those Member States that actually make use of the standards.

5.5.3 Social impacts

No social impacts are anticipated over and above those under the baseline for those Member States without national standards that would choose to retain the current status. In any instance, where Member States with more stringent national requirements would choose to align with the recommended EU minimum quality requirements, i.e. lower, their national standards some adverse impacts in terms of compromised public acceptance could be anticipated.

Conversely, adoption of the new EU wide standards (by those Member States without national standards) or alignment of less stringent national standards with more stringent EU wide recommendations would positively impact on promotion of public acceptance.

Social impacts associated with the Member States without national standards adopting the EU wide recommendations and Member States with less stringent standards choosing to align these with the proposed standards for water reuse in aquifer recharge would be as follows:

- **Public and occupational health.** The adoption of EU wide minimum water quality recommendations would promote a consistent level of protection of the human health and safety of individuals/populations. The option would also decrease the likelihood of health risks due to substances harmful to the natural environment. Furthermore, research and pilot testing might improve existing technologies, also in terms of safety and thus public health;
- **Employment and labour markets**. Overall, this option is not expected to have significant impacts on labour markets. The promotion of research and innovation on treatment technologies for aquifer recharge might increase the demand for qualified technical and scientific personnel. It is likely to trigger some demand for technical and scientific personnel and create some new jobs in water treatment, but this would be limited. It can reasonably be expected that water recycling for aquifer recharge would be a niche sector, so the macro-economic impact would be very limited (both in case of research and development of the topic that in case of future adoption of this practice);

[106] It should be noted, however, that innovation and economically viable changes would also take place without adoption of a new regulation.

- **Public acceptance.** Promotion of minimum water quality standards for aquifer recharge across the EU would promote consistent levels of consumer protection and would result in increased awareness about the quality of water being used. The establishment of an EU wide standards together with improved communication on actual risks and benefits of water reuse is expected to have a positive impact on confidence of the general public in the quality of the reused water and, therefore, on acceptance of water reuse as a water management tool; and
- **Governance and participation**. The development of EU wide standards, as well as the consequent promotion of research and innovation in the country, might bring the practice to the attention of the general public. Furthermore, the existence of EU wide standards, albeit non-binding, could positively steer public perception and acceptance of this practice.

5.5.4 Impacts identified in case studies

The review of the selected case studies identified some specific impacts. These are summarised below. Member States that do not currently have national standards would have complete freedom as to whether to adopt the non-binding standards or not. This decision will depend on a wide range of factors including potential demand for treated wastewater in the country, associated costs of treatment and supply, public health concerns and quantitative state of groundwater bodies.

In **Romania**, the Waters Law no. 107/1996 with further amendments explicitly prohibits the injection of wastewater into groundwater. Therefore, the non-binding standards could only be implemented following a change to the existing legal provisions. Changing the Waters Law is likely to be a slow and arduous process, especially since the practice of wastewater reuse does not have significant support at the national level. It should be noted that demand for aquifer recharge (in general, as well as using treated wastewater) in Romania is very low. Currently, groundwater resources are not overexploited and most aquifers recharge naturally and do not need to be recharged artificially, let alone with treated wastewater[107].

In situations, where national standards do exist, Member States will be making a choice whether to retain fully or partially their own standards (particularly if these are more stringent than the recommended minimum water quality requirements) or amend the national legislation bringing it in line with the proposed non-binding standards. A range of responses by different countries can be anticipated as is evident from the selected Member States case studies.

- Given the current aversion to using treated wastewater for groundwater recharge in **France** and the high importance given to the potential sanitary risks, it is not expected that non-binding standards for water reuse provided at European level would have any significant impact in the country;
- Similarly, **Cyprus** and **Greece** are expected to keep their own legal frameworks in relation to aquifer recharge, based on the case studies:
  - The Greek and Cypriot standards differ significantly in concept from the standards considered in this impact assessment. They are different regarding the categories of reclaimed water, the monitored parameters and the foreseen level of treatment for each category;
  - In some aspects the Greek standards seem to be more stringent as well as more inclusive in terms of examined risks (e.g. clogging, pathogens, combinations of aquifer type and application method); and
  - Since the instrument would not be mandatory, it is not expected that Greek or Cypriot authorities would fully adopt the new guidance/recommendation. Overall, environmental, economic and social impacts of this policy option would be similar to the baseline with no additional uptake of treated wastewater reuse for aquifer recharge taking place due to

[107] There is some potential interest in the use of infiltration ponds for treated wastewater discharge. This interest, however, is driven by the need to discharge treated wastewaters in locations where there are no surface waters receivers within reasonable distance (this is for example the case of many localities in Dobrogea). There is, therefore, a potential interest in developing standards that would stipulate minimum quality requirements for treated wastewater discharge to infiltration ponds (Appendix D, case study for Romania).

substantial technical, economic and social factors limiting the potential to expand wastewater reuse.

In **Spain,** Royal Decree 1620/2007 establishes thresholds that are more stringent than those being considered in this assessment, both in terms of quality criteria (maximum acceptable values; presence/absence of certain parameters according to type of water use) and risk management measures for reuse of treated wastewater in aquifer recharge. Spanish legislation only authorises recharge for environmental purposes, i.e. to replenish aquifers, and no changes to the national system are anticipated under this policy option (Appendix D, case study for Spain).

Given that artificial aquifer recharge with treated wastewater is not being practiced at present in **Italy**, the development of non-binding standards might promote research and pilot testing of aquifer recharge with treated effluents in the country. It is assumed that non-binding EU standards would not be transposed into national legislation (at least in the short-medium term), so that the practice would only be applied at the research and experimental level (Appendix D, case study for Italy).

5.6 Option Aq.3. Development of legally binding standards for water reuse for aquifer recharge

This policy option would introduce a legally binding requirement (i.e. Regulation or Directive) setting out minimum water quality requirements that must be complied with when using treated wastewater to recharge aquifers used to provide potable and non-potable water supplies. Specified water quality standards would be determined based on the end-use, i.e. whether the aquifer is used as a source of potable water or non-potable water.

Different end-uses require different levels of protection (with environmental compliance standards as a minimum), i.e. the standards proposed would not compromise the objectives and requirements of GWD, WFD and DWD. Applicable risk management measures and monitoring and evaluation requirements would also be specified.

Ultimately, development of legally binding minimum quality requirements is aimed at increasing uptake rates of treated wastewater reuse for aquifer recharge. In turn, increasing uptake of aquifer recharge across Europe would contribute to the increased resilience of different sectors, including the agricultural sector and the food industry, against water scarcity, droughts and climate change.

Environmental, economic and social impacts associated with development and promotion of legally binding standards for water reuse for aquifer recharge would depend on the existence of national standards and their relative stringency vis-à-vis the proposed requirements.

In situations where the use of treated wastewater for artificial groundwater recharge is currently prohibited, the introduction of legally binding quality standards would have no direct impact on a Member State, unless it chooses to commence water reuse for this purpose in the future. However, it can be expected that such an initiative at European level would provide a good basis for relaunching discussions on the use of treated wastewater for aquifer recharge in these countries. Taking into account the importance given to sanitary risks, legally binding standards at European level would probably remove some uncertainty around the issue and give some support to those in favour of using treated effluent for recharge. Determining potential uptake (in quantitative terms) would require further consultation with Member State authorities and relevant trade bodies on the final version of the proposed EU-wide standards.

Overall adoption of binding standards for aquifer recharge is likely to result in a range of different responses.

Member States that do not currently have national standards and do not employ treated wastewater reuse for aquifer recharge will still retain freedom as to whether to adopt the actual practice or not. This decision will depend on a wide range of factors including potential demand for treated wastewater in the country for this particular use, associated costs of treatment and supply and public health concerns. However, in comparison to non-binding standards this option would help to ensure overall coherence across the EU in relation to minimum quality requirements as and when individual Member States choose to adopt the practice.

In situations, where national standards for the reuse of treated wastewater for aquifer recharge do exist, the Member States will have a choice of retaining their own standards (if these are more stringent than the proposed minimum requirements) or fully or partially adjusting the national standards to meet the proposed legally binding minimum requirements. The later would be based on the evaluation of the administrative costs and the potential benefits to do so. In particular:

- Member States whose national standards are less stringent than the proposed EU wide minimum quality requirement would need to adopt the legally binding standards to ensure compliance. Member States would be faced with additional costs of treatment and monitoring; and
- Member States whose national standards are more stringent than the proposed EU wide minimum quality requirements would either choose to retain their relatively more stringent national standards or to fully or partially adopt the proposed EU wide requirements. This could result in a decreased levels of treatment required and, subsequently, lower energy consumption and wastewater treatment costs. In practice, Member States with relatively more stringent national standards are likely to retain these in order to avoid compromising public perception and acceptance by adopting lower standards. However, the option of aligning national standards would be available to these Member States and is explicitly considered in the descriptions of the case studies below.

Anticipated environmental, economic and social impacts under this option would be similar in nature and scale to those associated with the Aq2 policy option (with a slightly higher potential for uptake under the Aq2 option based on the fact that a binding instrument would send a stronger incentive from Member States to consider water reuse).

5.6.1 Impacts identified in case studies

Member States that do not currently have national standards and that do not employ treated wastewater reuse for aquifer recharge will still retain freedom as to whether to adopt the actual practice of wastewater reuse or not. This decision will depend on a wide range of factors including potential demand for treated wastewater in the country for this particular use, associated costs of treatment and supply and public health concerns. However, in comparison the non-binding standards this option would help to ensure overall coherence across the EU in relation to minimum quality requirements, as and when individual Member States choose to promote water reuse.

In **Romania**, the Waters Law prohibits the injection of wastewaters (even treated) into groundwater. Therefore, legally binding standards could only be implemented following the change to the existing legal provisions.

Similarly, in **France**, the use of treated wastewater for artificial groundwater recharge is prohibited and legally binding rules at EU level would have only a limited impact on the country. In 2013, the French Agency for Food, Environmental and Occupational Health and Safety assembled a group of experts in order to work on the qualitative evaluation of sanitary risks linked to artificial recharge of groundwater (Appendix D, case study for France). It should also be noted that one of the main barrier to using treated wastewater for aquifer recharge in France is a technological / scientific one, linked to the difficulty of collecting data on the self-purification capacity of soil. Casanova et al. (2013) state that only once this barrier is removed, will a regulatory evolution be possible. Introduction of EU wide minimum quality requirements, therefore, is not likely to have a significant positive impact on promoting water reuse for groundwater recharge in France, as it does not target the current main barrier to uptake (Appendix D, case study for France).

Finally, the quality standards considered in Appendix A apply to the water which is used as a source for artificial recharge. The indicated required water quality would therefore be that which is achieved after a specific post treatment of the water, before its actual use for recharge. In France, however, even if it is acknowledged that specific post-treatment before reuse is needed (Casanova et al., 2013), the main focus of research lies on the purification capacity of the soil, to ensure that the water has the correct quality once it has infiltrated in the soil. Requiring the correct water quality even before infiltration is not consistent with the current reflections and research efforts undertaken in France. The absence of institutional and policy support for the aquifer recharge practice is associated with the need to avoid introducing pollutants into aquifers. (Appendix D, case study for France)

In situations where national standards for the reuse of treated wastewater for aquifer recharge do exist, the Member States will have a choice of retaining their own standards (if these are more stringent than the proposed minimum requirements) or fully or partially adjusting the national standards to meet the proposed legally binding minimum requirements.

In **Spain,** Royal Decree 1620/2007 establishes thresholds that are more stringent than those being considered at EU level, both in terms of quality criteria (maximum acceptable values; presence/absence of certain parameters according to type of water use) and risk management measures both for reuse of treated wastewater in aquifer recharge. No additional changes to the national system are envisaged (Appendix D, case study for Spain).

In the case of **Greece**, the existing standards differ significantly in concept from the standards presented in Appendix A. They are different regarding the categories of reclaimed water, the monitored parameters and the foreseen level of treatment for each category. In some aspects the Greek standards seem to be more stringent as well as more inclusive in terms of examined risks (e.g. clogging, pathogens, combinations of aquifer type and application method). In other aspects (e.g. potable use/surface spreading) the Greek standards are less stringent (Appendix D, case study for Greece). Overall the monitoring costs are expected to be lower under the Greek standards as they include relatively more parameters with low to very low unit cost, whereas the standards presented in appendix A require more parameters with high to very high unit cost of sampling and testing. In general terms, implementation of the standards presented in Appendix A for potable water would mean higher cost for monitoring and treatment in comparison to the existing Greek standards (Appendix D, case study for Greece).

For non-potable aquifers the standards presented in Appendix A are relatively less stringent than the Greek standards. There are no parameters for microbiology (very low cost) and organics (low cost), fewer physical-chemical parameters (TSS, turbidity - very low cost) and less metals (medium cost) (see case study). At the same time standards presented in Appendix A would add several new physical-chemical parameters (nitrates, chlorides, sulphate, conductivity - low cost) and would include contaminants of emerging concern CECs (high and very high cost, see Appendix D). Overall the monitoring costs are expected to be lower under the Greek standards. Required treatment costs would also be lower under the standards presented in Appendix A, as disinfection is not implied. Greek standards for non-potable water require (a) secondary treatment and disinfection or (b) secondary, advanced treatment and disinfection. Overall, implementation of the standards presented in Appendix A for non-potable water would result in relatively higher cost of monitoring and lower cost of treatment. The total cost is anticipated to be similar to those under the Greek standards (Appendix D, case study for Greece).

In the case of **Cyprus**, the existing policy is not to use treated wastewater for potable aquifer recharge. In general terms, the main environmental and human health concern associated with artificial recharge is the degradation of the subsurface environment and groundwater due to the transport of pathogenic viruses with the recycled water. Furthermore, the clogging effect of boreholes caused by suspended solids, bacterial and recharge water is a phenomenon that limits the viability of artificial recharge (Appendix D, case study for Cyprus).

For non-potable aquifers the standards presented in Appendix A are less stringent than the Cypriot standards which require (a) secondary treatment and disinfection or (b) secondary, advanced treatment and disinfection. Implementation of the standards presented in Appendix A for non-potable water would result in lower cost of treatment but higher cost for monitoring. In particular, the standards presented in Appendix A includes contaminants of emerging concern (CECs) (e.g. biocides, hormones, pharmaceuticals, personal care products) for monitoring before potable or non-potable aquifer recharge that are not included in the Cypriot standards. Overall, the total cost is anticipated to be similar to the Cypriot standards (Appendix D, case study for Cyprus).

Given that aquifer recharge with treated wastewater is not being practiced at present in **Italy**, the development of legally binding EU standards is likely to promote the practice in the country. In particular, legally binding standards would need to be transposed in the national legislation, so that artificial aquifer recharge with treated effluent becomes an established and regulated practice in the country. After legal adoption, it can be expected that this practice would only be adopted at a pilot testing level for a few years, and that it would become common practice only afterwards. In any case, given the current level of knowledge, it is not possible to forecast to what extent this practice would be implemented. Given the low water availability in Southern regions, artificial groundwater recharge with treated effluent seems to be a promising practice; however, uncertainties exist about its costs and who will bear these costs (and who will invest in aquifer recharge with treated effluents) (Appendix D, case study for Italy).

5.7 Comparison of different policy options

The policy options defined were considered against an initial version of possible minimum standards for water reuse in agriculture irrigation and aquifer recharge. The assessment of the impacts is likely to change based on the refinement of the instrument and the policy options. This version was developed by the JRC is presented in Appendix A. The likely environmental and socio-economic impacts are compared below based on their effectiveness with regard to policy objectives, efficiency and coherence in line with the Better Regulation Guidelines (2015).

5.7.1 Effectiveness of the policy options

The policy options are first compared on the basis of their effectiveness to achieve the policy objectives (as defined in Section 4.1).

In particular, the general objective is to encourage efficient resource use and reduce pressures on the water environment, in particular water scarcity, by fostering the development of safe reuse of treated wastewater. The initiative aims to promote safe water reuse which addresses potential human health and environmental risks. This means achieving a higher uptake of appropriate water reuse solutions, where it proves cost effective (taking into consideration the wide range of potential costs and benefits), while ensuring the safety of reuse practices (i.e. providing a high level of confidence in the management of human health and environmental risks associated with reuse practices) and avoiding potential internal trade barriers for food products irrigated with reclaimed water. It should be highlighted that the policy options considered do not set any mandatory wastewater reuse targets; the aim is, therefore, to develop an instrument that would enable uptake of treated wastewater reuse across the Member States if and when they decide to adopt such a practice. The policy options considered would introduce minimum water quality requirements allowing Member States whose national standards are relatively more stringent to retain their national systems.

The degree of effectiveness with regard to this general policy objective will vary depending on the policy option and practices currently adopted in different Member States with regard to the use of treated wastewater.

Policy Options Ag1 (agricultural irrigation) and Aq1 (**aquifer recharge)** – Baseline for treated wastewater reuse for agricultural irrigation would not be effective in reaching the overall objective (of encouraging the development of safe reuse of treated wastewater, i.e. achieving a higher uptake of appropriate water reuse solutions, where it proves cost effective, while ensuring the safety of reuse practices (i.e. providing a high level of confidence in the management of human health and environmental risks associated with reuse practices) and avoiding potential internal trade barriers for food products irrigated with reclaimed water). As highlighted in Section 3, estimated treated wastewater reuse potential under the baseline (in the absence of further policy developments) is estimated at 1,700 million m^3/year by 2025 (compared against 1,100 million m^3/ year in 2015).

The effectiveness of **policy options Ag2 (agricultural irrigation) and Aq2 (aquifer recharge)** – development and promotion of non-binding Guidance/ Recommendation would vary across the Member States due to their non-binding nature.

- Member States with existing national standards for the reuse of treated wastewater (six Member States in total) are likely to retain their own national systems or to introduce marginal changes. For example this might include adding tetracycline or cefotaxime resistant E. Coli and Boron in the Greek standards, which would have a low impact on the total cost for monitoring and is not expected to cause any change in the level and cost of effluent treatment. At the same time, introduction of EU wide Guidance/ Recommendations on the reuse of treated wastewater might support the progress of existing national standards aiming to increase reuse of treated wastewater, through positively affecting public acceptance and providing further reassurance about the safety of such a use of treated wastewater (as indicated, for instance, by Greece). On the other hand, if a Member State with currently more stringent national reuse standards were to decide to align the national system with the proposed EU standards, this might result in a lower level of treatment required and, subsequently, lower costs of treatment;

- On the other hand, a large number of Member States (22) do not currently have national standards on the reuse of treated wastewater. Moreover, some of these countries explicitly prohibit certain types of treated wastewater reuse, such as for aquifer recharge. This is the case in Romania, for example, where, coupled with the fact that most aquifers in Romania charge naturally with surface and rainwater, no artificial recharge is expected to be required. Taking into consideration these two factors, introduction of the non-binding standards is not anticipated to result in the higher uptake in Romania (one of the case study member states); and
- This policy option is not expected to significantly increase uptake in treated wastewater reuse or to contribute significantly to addressing the key barriers to wastewater reuse discussed in the Section 3.

The implementation of policy options **Ag3 (agricultural irrigation)** and **Aq3 (aquifer recharge)** (i.e. development of a legally binding Regulation or Directive) is expected to result in higher uptake of treated wastewater reuse across the Member States where water scarcity is identified as a significant pressure and water reuse is deemed an effective measure. As indicated by BIO (2015), a volume in the order of 6,000 million m3/year by 2025 might be achievable in the case of both stronger regulatory and financial incentives at the EU level. Removing key barriers to increased uptake of the reuse of treated wastewater by Member States is, therefore, critical to tapping into full reuse potential (BIO, 2015).

The effectiveness of these policy options would vary across the Member States depending on the existence of any national standards and their relative stringency in comparison to the standards presented in Appendix A. In general terms, the effectiveness is anticipated to be higher in those Member States for which the absence of a clear legislative framework is seen as a major obstacle to water reuse and Member States whose national standards are lower in stringency than the proposed minimum requirements.

In particular, depending on the relative stringency of the existing national standards for the reuse of treated wastewater in the six Member States with standards in place, in comparison to the proposed EU standards, and their choice regarding retaining or aligning the national standards, these Member States would see an increased or decreased stringency of requirements (notwithstanding that member states with more stringent existing regimes could retain these, rather than reduce the level of protection). For instance, in Cyprus and Greece, the legally binding option could perform better in terms of improvement of public perception and raising confidence, removing a fragmented framework for agricultural irrigation using treated wastewater across Europe and resulting in lower treatment costs. Furthermore, in Greece, the volume of reclaimed water under the legally binding Regulation could rise by 80-100% (see Appendix D- case study for Greece).

Crucially, the Member States that do not currently have national standards on the reuse of treated wastewater and which are not interested in implementing use of treated wastewater would be not be affected. The standards considered in this assessment for water reuse in agricultural irrigation and aquifer recharge does not interfere with the Member States' decision on whether or not to develop water reuse and the extent to which water reuse should be encouraged.

5.7.2 Efficiency of the policy options

Policy Options Ag1 (agricultural irrigation) and Aq1 (**aquifer recharge)** – Business as Usual is not cost-effective as it involves many lost opportunities in terms of cost savings, and in terms of business development for the EU water industry (BIO, 2015).

Policy Options Ag2 (agricultural irrigation) and Aq2 (**aquifer recharge)** include development and promotion of non-binding Guidance/ Recommendation. These would involve limited additional treatment, monitoring and administrative costs. In particular, Member States that have national standards in place already are most likely to retain these, while Member States that do not have such national standards at present will retain the freedom to decide whether to engage in treated wastewater reuse practices and under what conditions. The policy options, however, would not contribute towards development of consistent quality requirements across the EU Member States.

Policy options **Ag3 (agricultural irrigation) and Aq3 (aquifer recharge)** includes development of a legally binding instrument. This would involve some administrative costs associated with development and adoption of the EU intervention, as well as its implementation and enforcement in the Member States that would choose to adopt treated wastewater reuse practices.

Member States which do not currently have national standards would benefit from having a clear regulatory framework for managing health and environmental risks of reuse if they choose to adopt the practice. At the same time, Member States that do not anticipate engaging in treated wastewater reuse practices would have to incur administrative costs of transposition (if the legal instrument is a Directive). This could be avoided if the legal instrument chosen was a Regulation.

Member States with existing national standards that are relatively more stringent than the minimum water quality requirements proposed are either anticipated to incur no additional costs or benefits if they choose to retain their national standards or would incur lower costs of treatment if they choose to align their national standards with relatively less stringent minimum requirements under the EU proposal (while not the intended objective of the proposed EU wide standards, this constitutes an available choice to this group of the Member States). In selected cases where Member States national standards were found to be less stringent, the countries would incur marginal increases in monitoring costs due to the higher number of parameters to be monitored.

In the context of treated wastewater reuse for **agricultural irrigation**, case studies for Cyprus, Italy and Greece suggest that the legally binding instrument would present more benefits in comparison to a recommendation/guidance, as the legally binding option would help to of improve public perception and raise confidence (that water reuse can be done safely). It would also remove the fragmented framework for using treated wastewater across Europe for agricultural irrigation, which could help to promote water reuse, through giving greater certainty in the safety of food irrigated with reused water. It also implies lower treatment costs, in cases where member states' with relatively more stringent national standards would choose not to go beyond the proposed EU minimum water quality requirements.

The case study for France and Spain suggests that both policy options may result in some additional costs to operators with the costs under the binding standards being higher than those under the recommendation/guidance approach and for farmers in compliance costs. In the case of the binding minimum requirements, adjusting national standards to the proposed standards may have a positive impact on the public perception of using treated wastewater for irrigation and might serve as a further guarantee of the overall safety of the system. Furthermore, strict water quality limits and additional parameters to be monitored would positively contribute to consumer protection and consumer confidence.

In the context of treated wastewater reuse for **aquifer recharge**, case studies for Greece and Cyprus suggest that neither option would affect further uptake of treated wastewater reuse in aquifer recharge, but a legally binding instrument would perform better in terms of improvement of public perception. The total costs for the binding instrument are expected to be broadly equivalent (to the baseline for these member states).

The Spanish case study identified little impacts and differences between the binding and non-binding options considering the current national legislation is very similar apart from one parameter. The main impact identified is that legally binding European standards could provide more transparency on groundwater overexploitation and recharge capacity.

In France, the introduction of non-legally binding EU standards is not expected to have an impact on the current situation as there is a reluctance to adopt aquifer recharge with treated wastewater practice. The introduction of legally binding EU standards, on the other hand, is likely to relaunch policy discussions and public debate on aquifer recharge with recycled water potentially resulting in improved public acceptance and uptake of this practice across Member States. Similarly, aquifer recharge using treated wastewater is explicitly prohibited in Romania and no changes to the practice would be anticipated in the short to medium term.

Finally, in Italy there is currently no aquifer recharge with treated waste water. Non-binding standards are expected to have a positive impact on research and pilot testing, and thus on developing knowledge on aquifer recharge with treated effluents –with a consequent positive impacts on research and innovation. Furthermore legally binding standards are expected to be transposed into national legislation, contributing to the uptake of this practice in the country. Overall, this option is expected to have a positive impact on research and innovation, job creation, available water resources among others

5.7.3 Coherence of the policy options

All policy options have to ensure they are fully coherent with other EU policies, supporting, in particular, achievement of the objectives set by the WFD and its daughter Directives, and by the Marine Strategy Framework Directive.

All policy options would contribute to the implementation of several other EU policies, in particular the EU climate change adaptation and disaster prevention policies, the EU biodiversity strategy, the resource-efficient Europe initiative, and the EU policy framework on phosphorus (BIO, 2015).

In addition, Option 3 would support the achievement of EU food safety legislation, by addressing upstream safety issues and in the case of agricultural irrigation promote addressing the internal market and trade barrier.

Appendix A
Policy Options for impact assessment

The detailed policy options are presented in this Appendix and based on a draft JRC proposal from March 2016. Note that this draft has now been superseded.

A1 Policy options for water reuse in agricultural irrigation

Three policy options are available, two of which are designed to achieve the overall policy objectives:

- Ag 1. Business as Usual;
- Ag 2. Promote non-binding standards for water reuse; and
- Ag 3. Promote legally binding standards for water reuse.

Table A1.3 Overview of options to consider

Stringency/ Instrument type	Quality requirements for water reuse for irrigation
Business as usual - baseline	Option Ag 1.
Guidance /Recommendation	Option Ag 2.
Legislative option	Option Ag 3.

Policy Option Ag.1 this is a non-interventionist option, reflecting the baseline scenario. The outcomes in terms of changes in agricultural reuse activity will be a consequence of national and EU policies already in place including how those policies may change in the absence of new, additional EU-level actions. Most importantly, the option considers current and future uptake rates of using reclaimed water in agricultural irrigation across the EU and associated environmental, economic and social impacts associated with 'baseline' reuse development. This option also considers that other actions under the circular economy action plan will go ahead.

Policy Option Ag. 2 introduces a non-legally binding document (e.g. guidance or recommendation) stipulating minimum quality requirements for using reclaimed wastewater for agricultural irrigation taking into account health and environmental risks. The water quality standards will be determined for different crop categories (i.e. different risk receptors) including:

- Food crops to be eaten raw (this may be sub-divided between root vegetable and tree fruits);
- Food crops that will be cooked or processed; and
- Non-food crops.

Many factors affect the uptake by crops of potential hazards within treated effluent, the exposure routes, and the ultimate human health risks and risks for the environment. The non-legally binding document will take these factors into account when specifying minimum quality requirements and the range of risk management measures.

Minimum quality requirements will be proposed as guidance without mandatory expectations. The costs and benefits of this policy option will be influenced by the impact on uptake of a voluntary measure, and the assessment takes this into account. There would be no policy **monitoring and evaluation** costs associated with a non-binding initiative.

Policy Option Ag. 3 involves developing a legally binding document (i.e. a Regulation or Directive) setting out quantifiable water quality requirements (minimum) that must be complied with when using reclaimed water in agricultural irrigation taking into account health and environmental risks. It includes risk management measures that must be complied with. The scope of that binding instrument does not include setting mandatory targets for water reuse (i.e. minimum percentage of agricultural irrigation to be carried out using recycled water).

- This option requires monitoring and evaluation activity and these costs are assessed. Note that while the final proposal will differ, this policy option is based on an initial draft that assumed that water quality monitoring is performed the point of discharge and would include the following parametersMicrobial contaminants:
  - Pathogens;
  - Viruses;
  - Parasites; and
  - Bacteria, .e. E. coli.
- Physico-chemical contaminants:
  - Total suspended solids (indication of secondary treatment effectiveness);
  - Turbidity (indication of the filtration effectiveness and suitability for disinfection); and
  - Biochemical Oxygen Demand (BODs, indication of secondary treatment effectiveness).

Calculation of monitoring costs will take into account monitoring frequency, sampling, and laboratory costs.

In addition monitoring of the implementation and effectiveness of the option is also taken into account through administrative costs.

Risk management plans

The risk management approaches the identification and the management of risks in a proactive way, looking systematically to all the hazards in the recycled water that could potentially affect human or environmental health. After hazard identification, the assessment of hazard-related risk is performed, followed by the identification of preventive measures and the establishment of monitoring programs for ensuring the effectiveness of selected preventive measures.

This type of approach is considered the most effective way to protect public and environmental health assuring appropriate water quality. The risk management framework is based on developing and implementing preventive risk management measures and applies the principles of the hazard analysis and critical control point (HACCP) system used in the food industry for many years.

The HACCP system consists in a systematic methodology for controlling safety hazards in a process and it includes two sequential phases, being the first the identification, the severity evaluation and the likelihood of occurrence of hazards, followed by the identification of critical control points and their monitoring criteria to establish controls that will reduce, prevent or eliminate the identified hazards. The identification of preventive measures to control the risk is performed by the “multiple barriers” approach. This approach, based on the use of more than one control measure as a barrier against hazards, incorporates the concept of producing reclaimed water of a quality that is “fit-for-purpose”.

Consistently with the latest edition of the WHO Guidelines for Drinking-water Quality (WHO 2004), the tolerable risk adopted in these documents is 10^{-6} DALYs per person per year (e.g.: pppy).

The corresponding degree of pathogen reduction that achieves this level of health protection is calculated following a step-by-step approach that includes Quantitative Microbial Risk Assessment (QMRA) and involves four main steps: hazard identification, dose-response, exposure assessment, and risk characterisation.

The log reductions of pathogens in wastewater treatment, as well as in any other preventive measure, are critical in reducing adverse health impacts. The WHO guidelines recommend minimum reductions of pathogens to meet the health-based target of a DALY loss of ≤10^{-6}pppy and to provide sufficient protection against bacterial, viral and protozoa infections.

In water reuse, this potential target log reductions can be achieved by combining wastewater treatment with other preventive measures. For the purpose of the IA we will use the table with the indicative treatment processes and additional measures as a proxy for risk management plans.

Water quality benchmarks

The criteria includes reclaimed water uses, indicative treatment processes, achievable pathogen log reductions (log removal credit for the polishing treatment process), additional preventive measures, exposure reductions and water quality objectives that support the “fit-for-purpose” approach adopted in this document

- Very high quality;
- High quality;
- Good quality; and
- Medium quality (secondary effluents, Directive 91/271/EC).

Table A1.4 Overview of reclaimed water quality category based on parameters

Reclaimed water quality category	***E. coli* (CFU/100 ml)**		**Total Suspended Solids (TSS) (mg/l)**		**Biochemical Oxygen Demand (BOD_5) (mg/l)**		**Turbidity (NTU)**	
	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
A: Very High quality	≤10	100	≤5	10	≤5	10	≤2	5
B: High quality	≤200	1,000	≤10	25	≤10	20	-	-
C: Good quality	≤1,000	10,000	≤35	35	≤25	25	-	-
D: Medium quality	-	-	≤35	35	≤25	25	-	-

Red values: 91/271/EEC minimum requirements

Treatment standards

The impacts were assessed against a simplified version of an instrument considering virus, protozoa and bacteria.

The following categories were defined:

- Food crops to be eaten raw: crops which are intended for human consumption to be eaten raw or unprocessed. **For the purpose of the analysis of impacts we considered that the water quality benchmark for this category is ‘very high quality’;**
- Processed food crops: crops which are intended for human consumption not to be eaten raw but after a treatment process (i.e. cooked, industrially processed). **For the purpose of the analysis of impacts we considered that the water quality benchmark for this category is ‘high quality’; and**

- Non-food crops: crops which are not intended for human consumption (e.g. pastures, forage, fiber, ornamental, seed, forest, and turf crops). **For the purpose of the analysis of impacts we considered that the water quality benchmark for this category is 'good quality'.**

Treatment process controls

Water treatment is the primary barrier applied to diminish the health risk. However, treatment processes can be used alone or in combination with additional preventive measures to meet health-based log reduction targets. The following pathogen log reduction for preventative measures are considered:

Table A1.3 Pathogen log reduction for preventive measures

Type of barrier/preventive measure	Pathogen reduction (log units)	Comments
Wastewater treatment	1-6	Pathogen reduction depends on type and degree of treatment technology selected.
On-farm options		
Drip irrigation of crops	2	
Drip irrigation of low-growing crops	2 (3)	Root crops and crops that grow just above, but partially in contact, with the soil (e.g. lettuce).(WHO, ISO) Crops with limited to no ground contact (e.g. capsicums)
Drip irrigation of high-growing crops	4 (5)	Crops the harvested parts of which are not in contact with the soil (e.g. tomatoes).(WHO, ISO) Raised crops with no ground contact (e.g. apples, apricots, grapes).
Subsurface drip irrigation of above ground crops	4 (6)	Where water does not ascend by capillary action to the ground surface.(ISO)
Spray drift control irrigation	1	Use of micro-sprinklers, (also WHO, ISO: 2-4 log units)
Spray buffer zones	1	Buffer zones (25-30m). Distance between irrigation areas and nearest public access point. Protection of residents near spray irrigation. Buffer zone should be 50-100m.(WHO)
Pathogen die-off (withholding periods)	0.5-2 per day (0.5 per day)	Die-off on crops that occurs between last irrigation cessation before harvest. The log unit reduction achieved depends on climate conditions, crop type (USEPA, WHO, ISO). Based on virus inactivation. Enteric bacteria are probably inactivated in a similar way. Protozoa will be inactivated if withholding periods involve desiccation.

The pathogen log reduction refers to the log reduction that has to be achieved from raw wastewater to reclaimed water. The pathogen reduction target attributed to treatment processes should be achieved provided that design specifications are complied with. This has to be accompanied by continuous operational monitoring to ensure that effective performance is maintained.

The following treatment chains are considered:

- Advanced treatment;
- Secondary treatment, filtration and high disinfection;
- Secondary treatment, and regular disinfection; and
- Secondary treatment without additional disinfection.

Table A1.4 Distinction of treatment level for specific uses

Pathogen reduction targets by category of use (log units) (V, P, B)a	Indicative treatment process	Pathogen reductions achievable by treatment (log units) (V, P, B)	Indicative additional preventive measures	Reductions in exposure to pathogens achievable by additional preventive measures (log units)b	Water quality requested (reclaimed water category)c
Food crops to be eaten raw					
V= 6.0 P= 5.0 B= 5.0	Advanced treatment to achieve total pathogen removal. OR Secondary treatment, filtration, and disinfection	V= 6.0 P= 5.0 B= 5.0	None required, although pathogen reduction will occur between harvesting and sale. Reclaimed water can be used for all crop applications, including spray irrigation and salad crops.	0.5 - 2 per day	To be determined on case-by-case basis, depending on technologies. Could include turbidity criteria, Ct or UV dose. [d] *E. coli* < 1 cfu/100ml Tetracycline, or cefotaxime resistant *E. coli* < 1 cfu/1000 ml
Processed food crops					
V= 6.0 P= 5.0 B= 5.0	Secondary treatment with > 25 days lagoon detention time and disinfection	V= 3.0 - 4.0 P= 2.0 - 4.0 B > 6.0	Crops with limited or no ground contact. Drip irrigation and no harvest of wet or dropped product.	3.0	BOD_5 < 20 mg/l TSS < 30 mg/l Disinfectant residual (minimum chlorine residual) or UV dose. *E. coli* < 100 cfu/100ml Tetracycline, or cefotaxime resistant E. coli < 10 cfu/100 ml
			Crops with ground contact and skin removed before consumption (e.g. watermelons). If spray irrigation, minimum 2 days between final irrigation and harvest.	3.0 - 4.0	
			Pathogen reduction between harvesting and sale.	0.5 per day	
			Public in vicinity of irrigation area: No access and drip or subsurface drip irrigation.	6.0	
			No access during irrigation and if spray irrigation, minimum 25-30 m buffer distance between irrigation areas and nearest public access point.	4.0	
V= 6.0 **P= 5.0** **B= 5.0**	Secondary treatment with disinfection	V= 2.0 - 3.0 P= 1.0 B > 6.0	Above-ground crops with subsurface drip irrigation.	4.0	BOD_5 < 20 mg/l TSS < 30 mg/l Disinfectant residual (minimum chlorine residual) or UV dose. *E. coli* < 100 cfu/100ml Tetracycline, or cefotaxime resistant *E. coli* < 10 cfu/100 ml
			Crops with no ground contact and skin removed before consumption (e.g. citrus, nuts). No harvest of wet or dropped product. If spray irrigation, minimum 2 days between final irrigation and harvest.	4.0	
			Pathogen reduction between harvesting and sale.	0.5	
			No access and drip or subsurface drip irrigation.	6.0	

Pathogen reduction targets by category of use (log units) (V, P, B)a	Indicative treatment process	Pathogen reductions achievable by treatment (log units) (V, P, B)	Indicative additional preventive measures	Reductions in exposure to pathogens achievable by additional preventive measures (log units)b	Water quality requested (reclaimed water category)c
			No access during irrigation and if spray irrigation, minimum 25-30 m buffer distance between irrigation areas and nearest public access point.	4.0	
V= 6.0 P= 5.0 B= 5.0	Secondary treatment without additional disinfection	V= 0.5 - 1.0 P= 0.5 - 2.0 B= 1.0 - 3.0	Crops with no ground contact and heavily processed (e.g. grapes for wine production, cereals).	5.0 – 6.0	BOD_5 < 20 mg/l TSS < 30 mg/l Disinfectant residual (minimum chlorine residual) or UV dose. *E. coli* < 1,000 cfu/100ml Tetracycline, or cefotaxime resistant *E. coli* < 100 cfu/100 ml
			Crops cooked/processed before consumption (e.g. potatoes, beetroot). No harvest of wet or dropped product. No spray irrigation.	5.0 – 6.0	
			Crops with no ground contact and skin removed before consumption.	6.0	
			Raised crops (e.g. apples, apricots, grapes). Drip irrigation and no harvest of wet or dropped product.	5.0	
			Pathogen reduction between harvesting and sale.	0.5 per day	
			No access and drip irrigation.	6.0	
			No access during irrigation and if spray irrigation, minimum 25-30 m buffer distance between irrigation areas and nearest public access point, and spray drift control (e.g. through part circle sprinklers with 180° inward throw, vegetation screening, or anemometer switching). or Extended buffer distances to > 50m.	5.0	
Non-food crops					
V= 5.0 **P= 3.5** **B= 4.0**	Secondary treatment without additional disinfection	V= 0.5 - 1.0 P= 0.5 - 2.0 B= 1.0 - 3.0	No access and drip irrigation.	6.0	*E. coli* < 10,000 cfu/100ml Tetracycline, or cefotaxime resistant *E. coli* < 1000 cfu/100 ml
			No access during irrigation and if spray irrigation, minimum 25-30 m buffer distance between irrigation areas and nearest public access point, and spray drift control (e.g. through part circle sprinklers with 180° inward throw, vegetation screening, or anemometer switching). or	5.0	

Pathogen reduction targets by category of use (log units) (V, P, B)a	Indicative treatment process	Pathogen reductions achievable by treatment (log units) (V, P, B)	Indicative additional preventive measures	Reductions in exposure to pathogens achievable by additional preventive measures (log units)b	Water quality requested (reclaimed water category)c
			Extended buffer distances to > 50m.		

a: V=virus; P=protozoa; B=bacteria
b: Exposure reductions are those listed in Table 1.
c: Water quality categories represent medians for *E. coli* and means of other parameters.
d: The aim is to demonstrate reliability of disinfection and ability to consistently achieve microbial quality.

Application controls

Monitoring of:

- Microbiological parameters:
  - E. coli: this is the classical and most referenced indicator microorganism for monitoring purposes; and
  - E. coli resistant to tetracyclines, sulfonamides or cephalosporins. These parameters can easily be associated with already implemented monitoring schemes.
- Physico-chemical parameters:
  - Total suspended solids (TSS): indication of secondary treatment effectiveness;
  - Turbidity: criteria to indicate filtration effectiveness and suitability for disinfection; and
  - Biochemical Oxygen Demand (BOD5): indication of secondary treatment effectiveness and potential for bacterial regrowth.

All these parameters are surrogates for performance relating to pathogen reduction.

A2 Policy options for water reuse in aquifer recharge

Three policy options are available, two of which are designed to achieve the overall policy objectives:

- Aq 1. Business as Usual;
- Aq 2. Promote non-binding (water quality) standards of treated wastewater to recharge aquifers; and
- Aq 3. Promote binding (Water quality) standards of treated wastewater to recharge aquifers.

Table A1.5 Policy options to increase aquifer recharge using reclaimed water

Instrument type	Minimum quality requirements for reuse in potable and non-potable aquifers
Business as Usual - Baseline	Option Aq 1
Guidance / Recommendation	Option Aq 2
Legislative option	Option Aq 3

The options will consider aquifer recharge of aquifers associated with potable and non-potable uses.

Policy Option Aq 1 this is a non-interventionist option, reflecting the baseline scenario. The outcomes in terms of changes in aquifer recharge activity will be a consequence of national and EU policies already in place (including any *committed* policy developments) including how those policies may change in the absence of new, additional EU-level actions. Included within this scenario are the existing requirements of EU Drinking Water Directive 98/83/EC, Groundwater Directive 2006/118/EC, and Water Framework Directive 2000/60/EC.

The outcomes of this policy are measured in terms of the environmental, economic and social impacts associated with 'baseline' activity.

Policy Option Aq 2 introduces a non-legally binding document (e.g. guidance or recommendations) stipulating minimum quality requirements for using reclaimed wastewater for aquifer recharge. Specified water quality standards are determined based on the end-use, i.e. whether the aquifer is used as a source of potable water or non-potable water. Different end-uses require different levels of protection (with environmental compliance standards as a minimum), i.e. the standards proposed will not compromise the objectives and requirements of GWD, WFD and DWD. The proposed non-mandatory Guidance or Recommendation also stipulates sources of wastewater that would be applicable to reuse, and a range of risk management measures.

The costs and benefits of this policy option will be influenced by the impact on uptake of a voluntary measure, and the assessment takes this into account.

Policy Option Aq 3 involves development of legally binding document (i.e. a Regulation or Directive) setting out minimum quality requirements to ensure safety of the environment and human health for water reuse to recharge aquifers used to provide potable supply and those that are not. The scope of that legislative instrument does not include setting mandatory targets for water reuse (i.e. minimum percentage of aquifer recharge volumes to use recycled water). As per option Aq 2, this policy specifies water quality standards in relation to both aquifer type / use function and the aquifer recharge method applied (e.g. infiltration, direct injection). It also specifies applicable risk management measures and monitoring and evaluation requirements. Mandatory policy requires monitoring and evaluation activity and these costs are assessed.

Risk management plans

The reclaimed water quality for aquifer recharge for non-potable uses is site-specific and use dependent. The facility should be designed to ensure that no reclaimed water reaches potable water supply aquifers (USEPA, 2012).

Treatment standards

The proposal considers two categories of reclaimed water use for aquifer recharge:

- Recharge of aquifers which are used as a potable water source; and
- Recharge of aquifers which are not used as a potable water source.

Potable use

The reclaimed water quality recommended for recharging aquifers that are used as a potable water source is the water quality requested for drinking water under the Drinking Water Directive 98/83/EC (DWD) concerning the quality of water intended for human consumption. **For the purposes of the minimum requirements, water intended for human consumption shall be wholesome and clean that is to say free from any microorganisms and from any substances which, in numbers or concentrations, constitute a potential danger to human health, and meets the minimum requirements set out in Annex I, Parts A and B of the Drinking Water Directive.** This recommendation is valid for the two main types of aquifer recharge methods, surface spreading and injection.

Table A1.6 Minimum requirements of the drinking water Directive

Parameter	Parametric value
Microbiological	
E.coli	0 /100ml – 0/250 ml*
Enterococci	0/100 ml – 0/250 ml*
Pseudomonas aeruginosa	0/250 ml*
Colony count 22 °C	100/ml*
Colony count 37 °C	20/ml*
Chemical parameters	
Acrylamide	0.10 ug/l
Antimony	5 ug/l
Arsenic	10 ug/l
Benzene	1.0 ug/l
Benzo(a)pyrene	0.010 ug/l
Boron	1.0 mg/l
Bromate	10 ug/l
Cadmium	5.0 ug/l
Chromium	50 ug/l
Copper	2.0 mg/l
Cyanide	50 ug/l
1,2-dichloroethane	3.0 ug/l
Epichlorohydrin	0.10 ug/l
Fluoride	1.5 mg/l
Lead	10 ug/l
Mercury	1.0 ug/l
Nickel	20 ug/l
Nitrate	50 mg/l
Nitrite	0.50 mg/l
Pesticides	0.10 ug/l
Pesticides — Total	0.50 ug/l
Polycyclic aromatic hydrocarbons	0.10 ug/l
Selenium	10 ug/l
Tetrachloroethene and Trichloroethene	10 ug/l

Parameter	Parametric value
Trihalomethanes — Total	100 ug/l
Vinyl chloride	0.50 ug/l

A range of treatment options are available such that any level of water quality can be achieved depending upon the use of the reclaimed water.

Non potable use

The reclaimed water quality recommended for recharging aquifers that are not used as a potable water source has to take into account the Groundwater Directive 2006/118/EC (GWD) on the protection of groundwater against pollution and deterioration. These measures include in particular (Article 1) "*criteria for the assessment of good groundwater chemical status; and criteria for the identification and reversal of significant and sustained upward trends and for the definition of starting points of trend reversals*". "Good groundwater chemical status" is the chemical status of a body of groundwater, which meets all the conditions set out in Table 2.3.2 of Annex V of the WFD.

For the purposes of assessing groundwater chemical status the GWD establishes in Annex I groundwater quality standards for nitrates and active substances in pesticides.

Table A1.7 Groundwater quality standards for nitrates and active substances in pesticides

Pollutant	Quality standards
Nitrates	**50 mg/l**
Active substances in pesticides, including their relevant metabolites, degradation and reaction products (1)	0.1 µg/l 0.5 µg /l (total) (2)
(1) "Pesticides" means plant protection products and biocidal products as defined in Article 2 of Directive 91/414/EEC and in Article 2 of Directive 98/83/EC, respectively.	
(2) "Total" means the sum of all individual pesticides detected and quantified in the monitoring procedure, including their relevant metabolites, degradation and reaction products.	

In order to protect the environment as a whole, and human health in particular, detrimental concentrations of harmful pollutants in groundwater must be avoided, prevented or reduced. Member States (MS) are expected to define threshold values for groundwater pollutants and indicators of pollution on a national, river basin or other appropriate level having regard to regional or even local conditions. The Directive establishes (Annex II, part B) a minimum list of pollutants and their indicators to be considered by MS. Further details on how groundwater should be protected are provided in the Groundwater Directive.

Table A1.8 Overview of pollutants and indicators to be considered in groundwater protection

Substances or ions or indicators which may occur both naturally and/or as a result of human activities	Man-made synthetic substances	Parameters indicative of saline or other intrusions
Arsenic, Cadmium, Lead, Mercury, Ammonium, Chloride, Sulphate	Trichloroethylene, Tetrachloroethylene	Conductivity*

Application controls

The methods for aquifer recharge considered are surface spreading and injection (including vadose zone injection and direct injection).

Surface spreading is a direct method of recharge whereby the water moves from the land surface to the aquifer by infiltration and percolation through the soil matrix.

Appendix B
Selection of Case Study Member States

The selection of suitable case study Member States aims to illustrate anticipated impacts of introducing non-binding and legally binding water quality standards for water reuse in irrigation and aquifer recharge.

The selection was based on a range of criteria and a screening of the availability of data.

B1 Agricultural irrigation

For agriculture irrigation, the selection of Member States is based on the criteria described in the table below. Considering that the policy options do not envisage minimum reuse target thereby there was no need to select non-water stressed Member States with no or little agricultural water use as there will be no impact from the initiative on these Member States. Instead, the selection was made in order to cover a range of situations including Member States with national legislation and Member States with very little water reuse so far.

Table B.1 Selection of case study Member States for agriculture irrigation

Criteria	Member States
Water stressed countries (WEI + >20%)	Cyprus, Malta, Italy, Spain, Portugal, Greece, UK
Water stressed countries with agricultural water use (conservatively above 5%)	Greece, Spain, Italy, Cyprus, Portugal
Member States that already reuse treated wastewater in irrigation	Greece, Spain, Italy, Cyprus, France, Portugal, Poland, Malta and the Netherlands.
Member States that have national water reuse guidelines / legislation	Greece, Spain, Italy, Cyprus, France, Portugal
Selected case study MSs	**Spain, Greece, Cyprus, Italy, France, Romania**

Greece, Spain, Cyprus, Italy and France appear in the four criteria and has such were identified as good candidate for case study. Portugal also appears in the four criteria, however, less information was identified so it was not selected. Romania and Poland were two Member States identified with low water reuse but potential water stress. As a result Romania was selected based on the availability of data and the expertise of the project team to show the possible impacts on a country with no existing legislation and little reuse experience.

B2 Aquifer recharge

For aquifer recharge, it was expected that the impacts would be local rather than at Member State level, as a result, we considered individual recharge schemes as source of information. These recharge schemes were explored in selected Member States. For this our selection reflected the diversity situations for aquifer recharge (e.g. fighting saline intrusion, pre-empting climate change impact) but also the availability of schemes and information.

Table B.2 Information considered for selection

Criteria	Member States
Water stressed countries that rely on GW resources (conservatively above 15%)	Cyprus, Malta, Italy, Spain, Portugal
Member States that already employ groundwater aquifer recharge using treated wastewater	Reclaimed domestic wastewater is used at 12 sites (4% of total volume) Cyprus, Germany, Spain, Belgium, Greece, Italy, France

Ultimately, the same Member States covered for agriculture irrigation were considered for aquifer recharge.

Appendix C
Information needs and sources

C1 Overview of data needs for the IA

The figure below presents the mapping of the data identified against each of the options of the impact assessment.

Figure C.1 Information needs for the IA

Appendix D
Member State case studies

D1 Current situation in selected Member States

Details on the current state of water resources and treated wastewater reuse in agricultural irrigation and aquifer recharge in selected Member States are presented in the section below. The selection covers Spain, Italy, Greece, Cyprus, France and Romania representing a wide range of Member States including countries with and without existing national standards on treated wastewater reuse, major and small users of treated wastewater in the EU as well as Member States where significant share of treated effluent from wastewater treatment plants is being reused.

Spain

State of water resources and treated wastewater reuse

As a result of low and variable rainfall (2/3 of the country suffers from infrequent rainfall – OECD, 2015), water has always been a limiting factor for Spanish economic development. Nonetheless, Spain has been able to harness the potential of water mostly for agricultural development, hydropower generation, tourism, and urban development. However, the Spanish economy is heavily dependent on water availability, specifically in its most competitive areas, such as tourism and agriculture, which have proven to be resilient to the global economic crisis.

As in other medium-high water-stressed areas in the world (abstracting around 30% of its total available renewable resources), freshwater resources in Spain are intensively used, mostly in the most water-scarce regions (i.e. south-eastern Spain) where population, visitors and the most water intensive activities tend to concentrate: i.e. 70% of annual visitors (68.1m tourists in 2015 – INE, 2016) go to the Mediterranean regions, the Atlantic coast of Andalusia and the archipelagos. This has resulted in water withdrawal rates and wastewater discharges that are already in excess of the capacity of natural sources and infrastructure to meet current demand, even in the absence of drought. Available evidence about climate change shows that long-term water availability will decrease in the near future.

Furthermore, water security is no longer related only to water availability, but also to water quality concerns and environmental sustainability. It refers to the ability to ensure the good functioning of the water cycle as a whole, to allow for the perennial use of water for water-reliant activities and specifically the production of food and services associated to the good health of aquatic ecosystems (López-Gunn et al., 2016).

Quantitative water management is related to quality objectives through the establishment of ecologic flows in many rivers, although these flows are generally not clearly related to the achievement of a good ecological status. Ensuring that the established e-flows guarantee a good ecological status is one of the recommendations from the EC in the WFD 4th implementation report (EC, 2015)

While traditional strategies to alleviate scarcity were focused on augmenting supply through dams and canals – thus explaining why Spain is one of the world's leaders in number of dams per million inhabitants, the country is also a pioneer in river basin planning, facing crop water security and climate variability concerns. As a result of that, Spanish RBMPs have been considering alternative water sources from the onset, with a prevailing standard regulating water reuse that was enacted in 2007.

Spain has mostly dealt with structural water scarcity and increasingly frequent drought events through alternative water sources at higher marginal costs (from groundwater, with increased energy costs due to lower water tables, desalination of brackish water and seawater, and reclaimed wastewater reuse). However, incentives have been in place to make these sources available but not to conserve the water that makes them meaningful nor to make them work at full capacity(Gómez et al., 2013)..

There is a remarkable contrast between financially inexpensive but increasingly scarce sources (i.e. groundwater) and expensive albeit abundant alternatives (i.e. desalinated water). Path dependency tends to favour the use of the former, thus reinforcing unsustainable trends. The latter (including reclaimed wastewater) is then used for emergency situations – the loss of economies of scale makes these sources financially less competitive.

Progress in the recovery of capital and operational costs is mostly limited to urban water services; in agriculture there is still a long way to go where measures to ensure the recovery of environmental and resource costs are limited (EC, 2015). Besides, water prices are low if compared to the cost of marginal resources and there is much leeway for improvement in terms of accounting for resource (mainly that related to water scarcity), and environmental costs.

Gross water abstraction declined by 8% during the period 2000-2010, but groundwater abstraction increased by 10% in the same period (OECD, 2015). These abstraction trends remain mostly stable since then.

In terms of **water reuse**, all of RBDs in Spain already consider water reuse in their RBMPs. Current data from the second cycle of RBMPs (all River Basin Districts included except Catalonia and Canary Islands, where the most updated data from the river basin authority have been used) shows that reclaimed water in Spain reached 413 hm^3/yr in 2013. Their estimations at the plan submission date approached 520 hm^3/yr for 2015 with extended projections in 2021. Should these projections and regional plans for water reuse – e.g. Madrid and Catalonia, be factored in, the total estimated volume would soar up to 1,150 hm^3/yr,[108] showing what actually a potential upper bound is if all planned investments are in fact implemented.

Total volumes disclosed in the Survey of Water Supply and Sanitation, according to official data from the Office for National Statistics (INE, 2015a) differ from the RBMPs data, with a total volume of water reuse of 531 hm^3 *per annum* in 2013. Disparities may be due to differing criteria on the year used as a "current reference" within RBMPs. The total amount of reclaimed wastewater was 11% of the total volume of wastewater treated in 2013. This share remained steady (10-12%) from 2007, when the Spanish water reuse regulation came into force. Before 2007, the average value was lower than 8%. Again, the situation was especially remarkable in SE Spain (including Segura and Júcar River Basin Districts, plus the Balearic Islands), where 62%, 55% and 48% of wastewater treated was reused in 2013, respectively (INE, 2015a).

Additional information is available from non-official sources. AEAS (Spanish Association of Water Supply and Sanitation Services) (2014) reported that the use of reclaimed wastewater in 2012 was around 9.7% of treated wastewater. 77.3%, as above, were reused in agriculture, 10.2% in other forms of irrigation (leisure areas), 9.7% to undetermined uses, 2.2% in manufacturing, and 0.6% for cleaning. Updated information produced by AEAS and reported by iAgua (2016) shows significant changes in these shares: irrigated agriculture (41%), other irrigation uses (31%), industrial (12%) and other undetermined uses (16%).

In turn, FENACORE (National Federation of Irrigation Districts) have recently projected water reuse in Spain in 2016 on the basis of information reported to the European Commission in the second cycle of river basin management plans. This yields a rough estimate of 400 million m^3/year of reused water out of a total urban wastewater volume of 3,500 million m^3/year.

The cost of water reuse treatments are asymmetric depending on the treatment used to meet legal water quality requirements: the upfront investment cost can vary from 5 €/m^3 produced/day (filtration) to 736 €/m^3 produced/day (chemical treatment with a lamella settling system, ultrafiltration, reverse osmosis) and operational and maintenance costs may vary from 0.04 €/m^3 (filtration, and disinfection or depth filtration) to 0.35-0.45 €/m^3/day (with lamella/double depth chemical precipitation, ultrafiltration, RO/EDR desalination and disinfection). A specific example of costing in a region with a consolidated capacity of reclaimed wastewater reuse (Valencia, see Molinos-Senante *et a*l., 2013) shows an average opex for secondary treatment of 0.26 €/m^3, 0.32 €/m^3 for tertiary treatment, and 0.57 €/m^3 for advanced treatments such as osmosis or ultrafiltration.

The **legal framework** for water reuse is quite an advanced one at EU level. Nationwide, water reuse is regulated by Royal Decree 1620/2007 (December 7th), which establishes quality criteria (maximum acceptable values, presence-absence for certain parameters according to the type of water use) as well as risk management measures including inter alia both for reuse of treated wastewater in agricultural irrigation and aquifer recharge.

[108] According to the draft National Plan for Water Reuse (MARM 2010a), which was not further developed and implemented as such

The Decree expressly forbids reclaimed water for the following uses:

- Human consumption, with the exception of a catastrophic event;
- Food industry, except process and cleaning waters, as in Art 2.1b) of Royal Decree 140/2003;
- Hospitals and alike;
- Filter-feeding molluscs aquaculture;
- Bathing waters (recreational uses);
- Cooling towers and evaporation condensers, with exemption criteria for some industrial uses;
- Fountains and ornamental plates in public or interior spaces of public buildings; and
- Any other use public health or environmental authorities may consider as a risk, whatever the time when the risk or the damage are perceived.

Hence, allowed uses are urban irrigation or other uses (section 1), agricultural irrigation (section 2), industrial uses (section 3), recreational uses (section 4), and environmental uses (i.e. aquifer recharge *inter alia*) (section 5).

Additional related regulations / guidelines / planning instruments include a) the already mentioned water reuse planning instrument, still in a stagnant, draft stage (the National Water Reuse Plan, MARM, 2010a); b) all the 2nd River Basin Management Plans already adopted (i.e. main RBDs, Balearic Islands, Galicia Coast and Andalusian RBDs (see BOE 2016a; 2016b) as they contemplate water reuse measures, and c) an official specific document containing guidelines for the application of Royal Decree 1620/2007 (MAGRAMA, 2010b).

As per water reuse in agriculture, Appendix I.A. of the Decree sets up water quality criteria for intestinal nematodes, *Escherichia coli*, suspended soils, turbidity, and additional criteria such as *Legionella spp*., *Taenia,* and complying with Environmental Quality Standards regarding several pollutants. Regarding water reuse for aquifer recharge, similar criteria are defined and others are added, such as nitrogen and NO_3, both for recharge through surface infiltration (indirect recharge) or injection (direct recharge).

In terms of monitoring, Appendix I.B of the Royal Decree 1620/2007in turn establishes the minimum sampling and testing frequencies for each quality parameter.

Agricultural irrigation

Conventional agriculture, dominated by extensive crops with low returns per hectare (cereals yield in 2012 amounted 2,843 kg/ha, average for both rain-fed and irrigated fields) (MAGRAMA, 2014), dependent on public infrastructure and EU subsidies (i.e. CAP) contrasts with a dynamic, intensive and highly productive agriculture driven by market stimulus and competitive advantages, with limited financial support either from the local government or the EU (if at all). The largest examples can be found in the Castile and León region, in central Spain, with an average size of 57.7 ha, while those in the southeast are amongst the smallest, with an average size between 5.07 and 11.72 ha (INE, 2014).

The overriding traditional model of agriculture requires limited labour and manufactured inputs; management practices do not demand sophisticated commercial and financial services; and output does not feed complex industrial processes or supply chains. In contrast, the relatively modern and thriving agriculture that dominates water-scarce Mediterranean basins requires increasingly more sophisticated inputs and labour skills, follows modern entrepreneurial practices, and supplies basic commodities for a complex and competitive agro-food manufacturing and logistics industry.

Whereas apparent productivity in the regions of Castile and León (central Spain) and Andalusia (southern Spain) is the same (0.56 €/m[109]^{3}), indirect water productivity in Andalusia is actually larger (1.75 €/m^{3}) than

[109] Value of agricultural output (Euro) per m^{3} of water added

that of Castile and León (1.65 €/m^3), showing that the Andalusian agriculture has more relevant forward linkages with the rest of the economy (Pérez et al., 2010).

In regions like Andalusia and Murcia the direct contribution of agriculture to the regional output and employment (4.2% and 4.5%, respectively) might be low (although higher than average), but its indirect and induced impact over the whole production chain makes it the central piece of the existing income and employment opportunities.

According to de Stefano et al. (2015), estimated water demand (surface and groundwater sources) for agriculture amounts to approximately 25,000 million m^3/year (or 79% of total water demand). Groundwater abstraction is estimated at circa 6,125-6,925 million m^3/year (19-22% of Spain´s total water demand) out of which 70-72% (4,300-5,000 million m^3/year) is used for around one third of irrigated land (0.9 million hectares, on the basis of 3.3 million of irrigated ha). Following INE (2015), available water for irrigation in Spain comes from surface sources (77%), groundwater (21%), and desalination or reuse (2%). Arable crops account for 56% of water for irrigation whereas 16% is for fruit trees, 10% for olive trees and vineyards, 9% for other crops and 8% for potatoes and vegetables. Irrigation techniques have moved away from gravity (still 37%) towards drop irrigation (37% also) and sprinkler (26%).

It is of paramount importance to highlight groundwater prices in areas of the country with high water scarcity, since this is critical to understanding some of the variables for further penetration of water reuse for agriculture. According to Custodio (2015) common prices for groundwater in SE Spain range between 0.3 and 0.5 €/m^3 (and can be higher depending on conjoint use and the cost of energy for pumping). In the Canary Islands usual prices are around 0.5 €/m^3 though during peak demand they can go beyond 1 €/m^3.

Aquifer recharge

According to the last implementation report of the WFD (EC, 2015), the number of delineated groundwater bodies (GWB) in Spain is 748, with an average size of 482 km^2 and a total area of more than 355,564 km^2. De Stefano et al. (2015) estimated that groundwater abstraction is around 6,125-6,925 million m^3/year i.e. around 22% of the total water demand. Agriculture is the main groundwater user (70-72%), followed by domestic supply (23-22%) and industry (6-5%) and, to a lesser extent, recreational uses (0.4%). The chemical status of GWB (% by number of bodies) was good for 66.0%, poor for 32.9% and unknown for 1.1%. On quantitative grounds, the status was good for almost three quarters (71.3%), poor for 27.3% and unknown for 1.5%.

Estimates from the DINA-MAR Research Project (Escalante, 2014) show that managed aquifer recharge (MAR) in Spain hits 380 million m^3/year. According to the DEMEAU Project (Hannappel et al., 2014), 25 out of the 270 European known MAR sites (9%) are in Spain, most of them (López-Vera, 2012) in Mediterranean regions.

At European scale, Spain is the European country where MAR for irrigation is most common. Environmental uses (e.g. to restore the hydraulic gradient to mitigate seawater intrusion at the Llobregat aquifer in Barcelona – by means of injection wells/ infiltration through infiltration ponds, and Marbella) are also common (as in other European countries such as Germany and the Netherlands). In Spain, in practice all MAR schemes are implemented in fluvial deposits. Main types of MAR are Aquifer Storage and Recovery (ASR) and Aquifer Storage Transfer and Recovery (ASTR) and infiltration ponds, followed by flooding and, to a lesser extent, by others such as pits and excess irrigation, riverbed scarification, and ditch and furrow.

There is no information available within the second cycle of RBMPs about specific volumes of treated wastewater used for aquifer recharge.

The mean investment cost ratio (€/m^3) differs according to the implemented MAR technique. Escalante (2014) provides examples on the basis of implemented projects: 9.75 €/m^3 for ponds; 0.80 €/m^3 for dams; 0.23–0.58 €/m^3 for deep boreholes (deep injection); 0.36 €/m^3 for medium-deep boreholes and 0.21 €/m^3 for surface MAR facilities (ponds, channels). 16% of the analysed area in the country (Iberian Peninsula and Balearic Islands, Canary Islands excluded: *circa* 500,000 km^2) has the potential for being used for MAR (i.e. 134,000 million m^3, i.e. 2 million m^3/km^2).

Cyprus

State of water resources and treated wastewater reuse

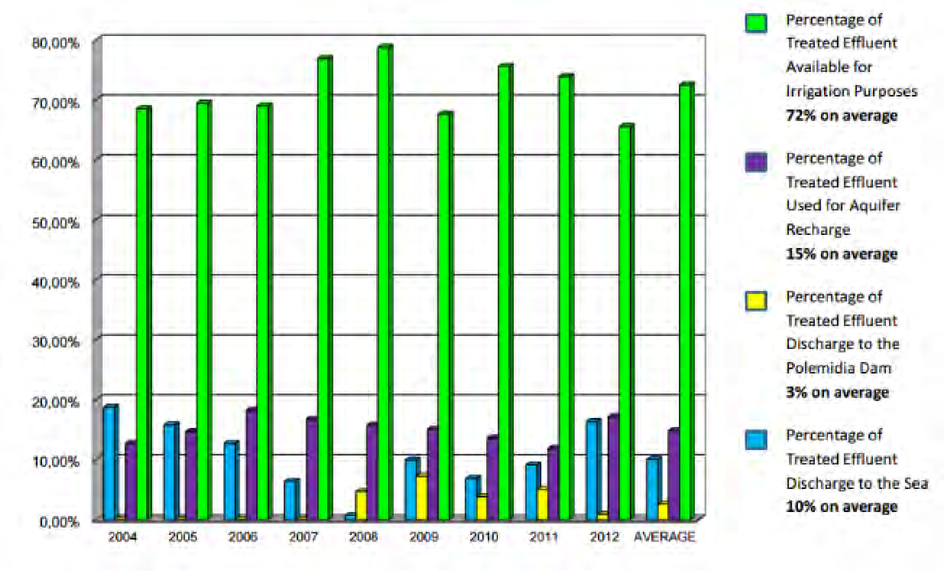
Cyprus, as far as natural water resources are concerned, depends solely on rainfall. The total annual water supply is 3030 million m^3/year, 89% of which is lost in evapotranspiration, leaving 321 million m^3 /year as useable water. Historically, droughts occur every two-to-three years due to the decline in rainfall. In the last fifty years, however, drought incidences have increased both in magnitude and frequency. Reuse of treated wastewater (known in Cyprus as “recycled water”) provides additional drought-proof water supply.

In terms of water stress, Cyprus is the most affected country of the European Union, with a water stress index of approximately 66%[110]. Domestic water use and agricultural irrigation are the two main sources of water demand in Cyprus.

In Cyprus, water reuse provides additional drought-proof water supply, favours a more local sourcing of water and avoids the use of drinking water quality water where such high quality is not needed. The potential for water reuse depends on the availability and accessibility of wastewater (i.e. the wastewater infrastructure) and the acceptability by potential end-users and consumers. Cyprus has adopted a ’Not a Drop of Water to the Sea’ policy encouraging the maximum capture of run-off by dam construction and handling of wastewater.

Almost 90[111]% of treated wastewater is reused, primarily for the irrigation of agricultural land, parks, gardens and public greens. In 2011, 12 million m^3/year of recycled water is given for irrigation and about 2,2 million m^3/year for artificial recharge of aquifers.

Figure D.1 Overview of uses of treated effluent in Cyprus



Source: Ministry of Agriculture, Natural Resources and Environment Water Development Department River Basin Management Plan, April 2011

However, a significant increase in the amounts of treated wastewater available in the future is expected. The capacity of the new Waste Water Treatment Plants was expected to reach up to 85 million m^3/year for long term (2025)[112].

110 Eurostat tsdnr310 | Publication date: 19 February 2016, CET (Water Exploitation Index - Percentage)

111 For 2004-2013 – 89.32% according to competent authority communication

112 Ministry of Agriculture, Natural Resources and Environment Water Development Department River Basin Management Plan, April 2011

Cyprus is one of the Member States where water reuse provisions are fully integrated into the legislation on urban wastewater treatment and discharge (State Law N.106(I)/2002, as amended). Quality criteria for the treated wastewater take the specific conditions of Cyprus into account. In particular, conventional secondary treatment has been preferred to stabilisation ponds in some areas because of the high cost of land (coastal areas) or for protection of environmental and aesthetic amenities for tourism.

Different uses of treated wastewater require different levels of treatment and, by extension, costs. A summary of the different treatment processes required for different uses is presented in the table below[113].

Table D.1 Summary of estimated water reclamation treatment process

Reuse alternative	Recommended treatment process
Agricultural irrigation	Activated sludge
Livestock and wildlife watering	Trickling filter
Power plant and industrial cooling	Rotating biological contactors
Urban irrigation – landscape	Activated sludge, filtration of secondary effluent
Groundwater recharge – spreading basins	Infiltration – percolation
Groundwater recharge – injection wells	Activated sludge, filtration of secondary effluent, carbon adsorption, reverse osmosis of advanced wastewater treatment effluent

Agricultural irrigation

In Cyprus, the use of recycled water has mostly been for irrigation and to mitigate the overdependence of agriculture on groundwater[114,115]. In Cyprus about 25 million m³/year of wastewater is collected and used for irrigation after tertiary treatment. It is anticipated that most of the recycled water, about 55 to 60%, is used for amenity purposes such as hotel gardens, parks and golf courses. Most treated wastewater (12 million m³/year) is used directly for irrigation with orchards being the most irrigated crops, such as citrus and olive trees, but water is also used for fodder crops.

According to information made available by the Water Development Department (WDD), the acceptance of using recycled water from farmers was initially slow (period 2002-2005) but in time it has increased significantly

According to information made available by the Water Development Department (WDD), the acceptance of using recycled water from farmers was initially slow but in time it has increased significantly.

Separate regulation, i.e. Cyprus Regulation K.D.269/2005 specifies the reclaimed water quality criteria for treated wastewater produced from agglomerations with less than 2,000 population equivalent. For agglomerations of more than 2,000 population equivalent (p.e.), the quality characteristics that must be met for the use of the treated effluent are specified within Wastewater Discharge Permits, issued by the Ministry of Agriculture for the Sewerage Boards and the Water Development Department.

The prevailing treatment technology was, until recently, conventional activated sludge treatment with secondary clarifiers followed by sand filtration and chlorination. However, most new projects under planning (new wastewater treatment plants as well as extension of existing ones) are considering advanced

[113] WASTEWATER AS VALUABLE WATER RESOURCE- CONCERNS, CONSTRAINTS AND REQUIREMENTS RELATED TO RECLAMATION, RECYCLING AND REUSE, 2005, D. Fatta and N. Kythreotou
[114] Pashiardis, S. Trends of precipitation in Cyprus rainfall analysis for agricultural planning. In Proceedings of the 1st Technical Workshop of the Mediterranean Component of CLIMAGRI Project on Climate Change and Agriculture, Rome, Italy, 25–27 September 2002
[115] Eighth Report on the Implementation Status and the Programmes for Implementation (as required by Article 17) of Council Directive 91/271/EEC concerning urban waste water treatment

technologies such as membrane application, e.g. bioreactor technology (Larnaca, Limassol, and Nicosia) or reverse osmosis.

Cyprus adopted water quality standards for wastewater reuse in 2005 and is prohibiting the irrigation of treated wastewater for vegetables that are consumed raw, crops for exporting, and ornamental plants.

Yearly water needs of irrigation amounts to an average of 178.5 million m^3/year; however, as this demand is rarely satisfied, the actual water consumption in agriculture fluctuates around 150 million m^3/year. Irrigated agriculture accounts for 88% of this amount (or 132 million m^3 of water per year) while accounting for only 28% of the total area under crops. Agricultural sector accounts for around 60% of total Cyprus' water consumption[116].

In Cyprus, the current nationally set objective is to replace 40% of agricultural freshwater requirements by reclaimed water.

Costs for construction and operation of municipal wastewater collection and treatment infrastructure are funded by the local communities through the sewerage rates. Tertiary treatment and reclaimed water distribution networks are financed and operated by the government, through the Water Development Department. Customers are charged different prices for reclaimed water depending on the end use.

Table D.2 Selling rates of the tertiary treated effluent and freshwater in Cyprus (WDD,2008)

	Use	Tertiary Treated Effluent	Fresh not filtered water from government water works
	Irrigation water	EURO Cent/m3	EURO Cent/m3
1	For Irrigation divisions for agricultural production	0.05	0.15
2	For Persons for agricultural production	0.07	0.17
3	For sports	0.15	0.34
4	For irrigation of hotels green areas and gardens	0.15	0.34
5	For pumping from an aquifer recharged by the treated effluent	0.08	
6	For over consumption for the items 1 to 5	Increase by 50%	0.56

Source: WDD, 2008 costs

Reused water tariffs in Cyprus range from 33%-44% of freshwater rates, ratios which appear typical for the EU Mediterranean islands[117]. The price reflects the application of substantial subsidies to reclaimed water supplies to encourage wider uptake, which may be at odds with the need for greater cost recovery in water treatment and management (BIO, 2015). Although such subsidised price structures have been in place for many years to incentivise take-up, price rates are usually based on intuitive judgements by utilities of the level of willingness to accept reclaimed supplies amongst different groups rather than empirical evidence of the price at which users would begin to accept these supplies over conventional freshwater. (BIO, 2015)

Research focused on irrigation of forage and citrus revealed no adverse impacts on using treated wastewater on either soil physicochemical properties or heavy metal content, nor on the heavy metal content of agricultural products. Similarly, research results concerning wastewater irrigation of tomato crops showed no accumulation of heavy metals in tomatoes, whereas total coliforms and faecal coliforms were not quantified in tomato flesh or peel; and E.coli, Salmonella spp and Listeria spp were not detected in tomato homogenates. Research on pharmaceutical compounds detected traces of these compounds in treated

[116] Arcadis, et al. (2012). The Role of Water Pricing and Water Allocation in Agriculture in Delivering Sustainable Water Use in Agriculture.
117 Hidalgo & Irusta, 2005

effluent but further research is on-going to assess whether they are being taken up by plants under field conditions. (Appendix D- case study for Cyprus)

Aquifer recharge

In Cyprus almost all the aquifers are over-exploited and, for many of them, water quality has deteriorated due to seawater intrusion. In particular, characterising water bodies according to requirements of the Water Framework Directive, around 80% of the groundwater bodies had been assessed as being at risk of failing to achieve a "good status" by 2015. This is mainly due to over-pumping, saltwater intrusion, high nitrate concentrations caused by agricultural activities[118].

Further action, therefore, is required for reducing aquifer extraction to a level which will allow the aquifers to recover. This can be achieved with very careful management that is focused mainly in two methods: first with the drastic reduction of pumping to sustainable levels and second with the increase of their recharge with natural and artificial methods. Managed Aquifer Recharge (MAR) is becoming an increasingly attractive water management option, especially in semi-arid areas. Artificial recharge using treated wastewater in depleted aquifers, via deep boreholes, is an internationally acceptable practice, which is compatible with Directive 2000/60/EC and may contribute to cover a part of irrigation needs, as well as the sustainable water resources management in many areas[119]. It does, however, have a number of limitations; with the degradation of subsurface environment and groundwater due to the transport of pathogenic viruses with the recycled water being the main environmental issue associated with artificial recharge. Furthermore, the clogging effect of boreholes caused by suspended solids, bacterial and recharge water is a phenomenon that limits the viability of artificial recharge.

In Cyprus, the lack of suitable site selection is one of the limiting factors in applying groundwater recharge. The process of selecting suitable locations includes: hydrogeological conditions, availability and quality of wastewater, possible benefits, economic evaluation and environmental considerations [27]. The wastewater should be pre-treated to improve its physico-chemical characteristics. The pre-treatment includes ultrafiltration and/or inverse osmosis. Membrane techniques are successful in producing wastewater with low values of TDS and nutrient content. The lack of field studies on the fate and transport of priority substances, heavy metals and pharmaceutical products within the recharged aquifer is also an important consideration.

On the other hand, important advantages of aquifer recharge include:

- Seawater intrusion being controlled;
- Provision of storage of effluent water for subsequent retrieval and reuse;
- The aquifer serving as an eventual natural distribution system;
- Further purification of effluent water (reduced biological load); and
- Saving of equal quantities of fresh water for domestic use.

In Cyprus, four candidate regions have been selected on the basis of water scarcity/ shortage or deficiency and aridity of the area, social and economic characteristics and the complexity of the water system. Recycled water is used to recharge depleted aquifers and reduce sea-water intrusion. This is the method used in Paphos, where the Ezousa aquifer is recharged artificially with 2–3 million m^3 treated wastewater per year, which is then re-abstracted for irrigation[120,121].

118 MANRE,2005

119 . Voudouris, K.; Diamantopoulou, P.; Giannatos, G.; Zannis, P. Groundwater recharge via deep boreholes in Patras industrial area aquifer system (NW Peloponnesus, Greece). Bull. Eng. Geol. Environ. 2006, 65, 297-308.

[120] Water Scarcity in Cyprus: A Review and Call forIntegrated Policy, Anastasia Sofroniou and Steven Bishop

[121] Eighth Report on the Implementation Status and the Programmes for Implementation (as required by Article 17) of Council Directive 91/271/EEC concerning urban waste water treatment

France

State of water resources and treated wastewater reuse

Although France does not experience serious water stress (with its Water Exploitation Index being around 15.5% for the period 2008-2012 (Eurostat)), the analysis of natural flows in France shows that low water periods are getting more frequent and more serious in the last 40 years (1970-2010), particularly affecting the South of France (ONEMA, 2011). The consumption of water for farming is growing particularly strongly in South-Western France and in the Paris region (TYPSA, 2013).

In addition to the growing demand for water for agricultural purposes, some irrigated crops (such as corn) have become more widespread and periodic droughts have occurred. Over the last 20 years droughts events affected the regions traditionally considered to be the wettest, in Western and North-Western France. In more than one-third of the country, water tables are falling as the autumn and winter rains are no longer making up for the amounts drawn up in spring and summer. Faced with this situation, the authorities have occasionally imposed restrictions on water use, a very unusual practice in France. It is also worth recalling that around fifteen French departments are situated in an area with a Mediterranean climate similar to that of Northern Spain and Italy, well-suited to market gardening, fruit farming and mass tourism.

In France, water reuse systems are already in place, and legally binding standards for reuse are in place for the agricultural sector and water reuse for green and recreational areas.

There are no recent data on the total volume of reused water in France but the latest data from a 2007 report indicate that water reuse was 19,200 m^3/day corresponding to about 7 million m^3/year (according to Jimenez et al.[122]). At present, there are about 40 reuse schemes in France, most of which are dedicated to irrigation (agriculture, public areas, golf courses and racecourses) (SYNTEAU, 2014). Latest available data indicate that around 55 reuse schemes are now in place in the country[123].

Agricultural irrigation

Agriculture is the main user of water in France (48% of the water used in 2004[124]). The total agricultural area equipped for irrigation amounts to 27.7 million hectares; however, in 2010, it was reported that irrigation actually occurred on 1.6 million hectares, corresponding to a total water use of 2.7 billion m^3 per year.

The irrigated area by type of crop is illustrated in the figure below[125].

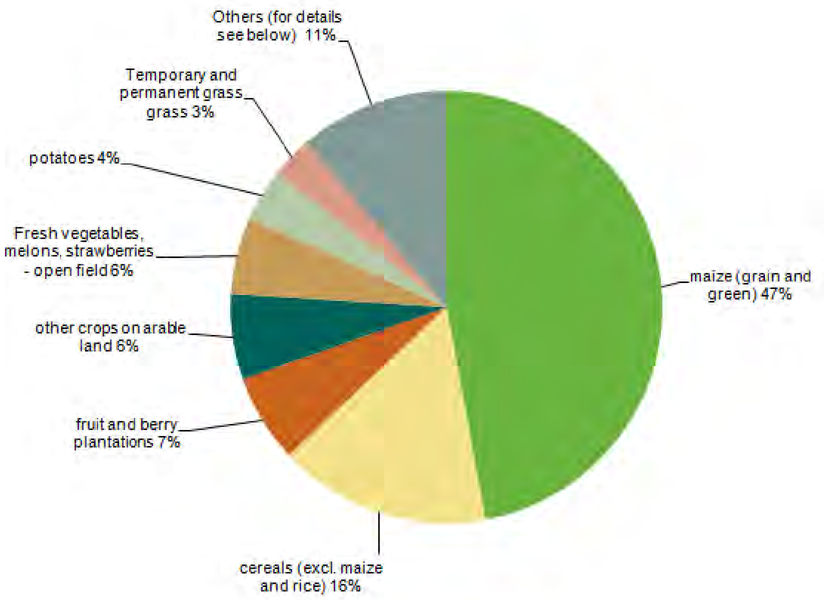
[122] However, the yearly estimate must be taken as indicative (or as a maximum potential yearly production), as it is calculated taking the daily production and multiplying it by 365. However, it must be noted that reused water is used mostly during the summer period.

[123] Communication from French competent authority

[124] France Nature Environnement, 2008.

[125] France Nature Environnement, 2008.

Figure D.2 Irrigated area by type of crop (2010)



The reuse of wastewater for irrigation purposes is still little developed in France. On the one hand, France is hardly facing water scarcity issues – and when it does, scarcity events unfold at the local scale. In fact, water reuse for irrigation is limited to particular regions, such as islands or areas with a high water demand and uses possibly conflicting with potable use. On the other hand, the price of reused water is higher than the price of conventional water, so there is no economic incentive to switch to reused water. In particular, in France, both volumetric and mixed tariffs are applied to the provision of irrigation water. The EEA (2013) reports flat tariffs ranging between 38 and 157 EUR/year, combined with volumetric rates ranging between 0.06 and 0.09 EUR/m^3. Tariffs paid by farmers cover 100% of operation and maintenance costs, but they do not fully cover investment costs: depending on the area, revenues from tariffs cover from 15% to 95% of investments costs (55% on average)[126].

At the end of the 1990s, only around twenty water reuse projects could be found in France; all projects were set up for irrigation of crops, green spaces and golf courses. The largest water recycling project provides irrigation water to 2,300 ha[127]. More updated data are not available, although it seems that few additional projects have been set up since then. According to an ongoing study by CEREMA, the number of operating water reuse projects has more than doubled since 2010[128].

The French population already eats fruits and vegetables imported from countries where water reuse for irrigation is frequent (e.g. Spain). Despite this, a third of the French population declared themselves not ready to eat fruits and vegetables irrigated with recycled water (CGDD, May 2014).

Aquifer recharge

The volume of groundwater in France is estimated at 2000 billion m^3 per year, of which 100 billion m^3 per year flow through springs and water courses. About 7 billion m^3 per year are extracted from groundwater through the exploitation of springs, wells and drillings. Half of the water is used for drinking water[129], covering two thirds of the demand for drinking water (BRGM, 2016).

[126] EEA, 2013. Assessment of cost recovery through pricing of water. Technical report No 16/2013. http://www.eea.europa.eu/publications/assessment-of-full-cost-recovery
[127] http://www.ecoumenegolf.org/XEauXLAZAROVA.pdf
[128] The ongoing CEREMA study aims to establish an assessment of reuse in France and the relevant places to develop the reuse. Information on the original study could not be found, this information was provided by French Competent Authority (personal communication).
[129] http://www.eaufrance.fr/comprendre/les-milieux-aquatiques/eaux-souterraines

Of the 646 groundwater bodies in France, 90.6% were in a good quantitative status in 2013. Water bodies with less than good status are mainly situated in the South-East and the centre, the Mediterranean region as well as the islands Réunion and Mayotte. The main reasons for not reaching good status are overexploitation of the aquifers compared to their recharge, but also salt water intrusion (Réunion, Mediterranean region).

There are no official statistics on artificial groundwater recharge in France. An inventory from the year 2013 (Casanova et al., 2013) listed 75 sites of artificial groundwater recharge on the French national territory. The status of 48 out of them is known with certainty, without certainty for 8 and unknown for 19. Two-thirds of the sites for which the status is known are situated in the (former) regions Nord-Pas-de-Calais, Midi-Pyrénées and PACA. Only about 20 of them are still active today (Casanova et al., 2013). The techniques applied are either indirect injection (infiltration basins) or direct injection (via drilling) (BRGM, 2016).

In most of the known cases of artificial groundwater recharge in France, the primary objective is to support an overexploited groundwater body. The second objective is the improvement of the quality of the groundwater bodies through significantly diminishing the concentrations of certain chemicals by dilution (e.g. nitrates, pesticides). The latter allows for the application of simpler and more economic final treatments to make the water suitable for drinking water purposes (Casanova et al., 2013).

In almost all cases which are currently active in France, surface water is the source of water used for artificial recharge. This is mainly due to the availability of the resource. Artificial recharge with treated wastewater is not prohibited. However, this is not regulated by existing legislation, as quality requirements and allowed uses of treated wastewater are only regulated for irrigation of crops and green areas[130].

While direct injection of treated wastewater in the aquifer has never taken place in France, two research projects on indirect infiltration of treated effluent have been carried out by BRGM – the public service provider for the quantitative groundwater management in France – and the company Veolia until 2011 (REGAL and RECHARGE) (BRGM, 2016).

Greece

State of water resources and treated wastewater reuse

In Greece the theoretical long-term annual freshwater availability is 72,000 million m^3/year.[131] Due to a range of technical and economic reasons the amount of freshwater which is readily available for abstraction and use is much lower. The annual freshwater abstractions constitute only 13% of the theoretical availability and are estimated at 9,539 million m^3/year [1]. The major water user in Greece is irrigated agriculture, which accounts for 84% of the total water use.

Half of the Greek RBDs (7 out of 14) face water scarcity issues (Water Exploitation Index (WEI[132])+>20%) with these 7 RBDs being among the twenty most water-scarce RBDs of Europe.[133]

Wastewater reuse in Greece is being regulated by JMD 145116/2011 (GG B 354) and JMD 191002/2013 (GG B 2220), which aims to promote wastewater reuse and protect public health by establishing criteria and standards on its practice. Their scope extends to urban and conventional industrial wastewater (included in JMD 5673/400/97), for restricted and unrestricted irrigation in agriculture, urban and peri-urban use, aquifer recharge (including protected aquifers) and industrial use.

[130] Arrêté du 2 août 2010 relatif à l'utilisation d'eaux issues du traitement d'épuration des eaux résiduaires urbaines pour l'irrigation de cultures ou d'espaces verts https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022753522&dateTexte=&categorieLien=id

[131] Eurostat data, Water statistics, Agricultural statistics, Crop statistics, Agri-environmental indicators, Agricultural Census in Greece.

[132] The water exploitation index (WEI) in a country is the mean annual total demand for freshwater divided by the long-term average freshwater resources. The following threshold values/ranges for the water exploitation index have been used to indicate levels of water stress: (a) non-stressed countries < 10%; (b) low stress 10 to < 20%; (c) stressed 20% to < 40%; and (d) severe water stress ≥ 40%. (EEA, 2015. http://www.eea.europa.eu/data-and-maps/indicators/water-exploitation-index)

[133] ETC/ICM, 2016. Use of freshwater resources in Europe 2002–2012. Supplementary document to the European Environment Agency's core set indicator 018. ETC/ICM Technical Report 1/2016, Magdeburg: European Topic Centre on inland, coastal and marine waters, 62 pp

The reported estimates for the current and potential volumes of reused wastewater differ significantly. The average daily wastewater reuse is estimated at 28,000 m^3/day (or 10.2 million m^3/year)[134], while in the AQUAREC project the average annual wastewater reuse was estimated at 23 million m^3/year [135]. The future potential for wastewater reuse in Greece (2025) was modelled at 57 million m^3/year [136] in the AQUAREC project, while another study estimated it at 242 million m^3/year [137].

When compared to the total water use in the country, wastewater reuse in Greece accounts for less than 1%). Furthermore, the share of reclaimed wastewater, when compared to the total treated effluent is below 5%[138]. In addition, a water balance analysis has revealed that over 83% of the treated effluent from wastewater treatment plants are produced in regions with a water deficit. Furthermore, over 88% of the effluents from WWTP are discharged at less than 5 km from available farmland, which implies that the additional cost for wastewater reuse in irrigation could possibly be technically and economically affordable[139].

Agricultural irrigation

The reuse of treated urban wastewater for agricultural irrigation may require differentiation depending on the type of crops (e.g. food crops to be eaten raw, food crops to be cooked or processed, non-food crops, ornamental flowers), the irrigation equipment (sprinklers used or not) and the status of access for the public and for animals (restricted or unrestricted).

It is estimated that 84% of the total water use in Greece is taken up by irrigated agriculture (3,897 million m^3/year). The average irrigation intensity is 3,800 m^3/ha, which is the 6th highest in Europe[140].

Irrigation water in Greece is billed in a number of ways with the average price ranging between 0.02-0.70 €/m^3 [141] for volumetric billing, 73-286.3 €/ha [142] for flat rates by crop type and 45-243.1 €/ha for flat rates by irrigation system[143]. There are no abstraction or pollution charges. The price of self-abstracted groundwater can be roughly approximated using the electricity consumption for pumping. For an expected range of depths it could range between 0.02-0.03 €/m^3 [3]. The price of desalination water is 0.3-0.7 €/m^3 [144].Since the monetary cost of (usually illegal) self-abstracted on-farm surface water and groundwater is very low (<0.03 €/m^3), these users are unlikely to be interested in using reclaimed water. At least 32% of the total holdings rely on self-abstracted groundwater. Taking into account the price of desalination water (0.3-0.7 €/m^3) it is concluded that wastewater reuse might be more cost-efficient than desalination in coastal areas and islands with existing WWTPs. It is also expected that reclaimed water would be appealing to users of off-farm water supply, which account for nearly 63% of the total irrigation water users. Given that the existing irrigation freshwater tariffs range significantly across the country (0.02-0.70 €/m^3) and reported price of reclaimed water ranges from 0 (Salonica case study- see Box 1) to 0.12-0.30 €/m^3 (Pinios case study –see Box 2), there is not sufficient data to make the comparison between the two types of water.

Over recent years at least 9 wastewater reuse projects for crop irrigation have been implemented in Greece with EYATH in Salonica (2,500 ha; corn, cotton, sugarbeet, rice, alfalfa) being the most important project[145].

[134] Kellis M., Kalavrouziotis, I.K., and Gikas, P., 2013. Review of wastewater reuse in the Mediterranean countries, focusing on regulations and policies for municipal and industrial applications. Global NEST Journal, Vol. 15, No. 3, pp. 333-350.
[135] Hochstrat et al., 2006. Report on integrated water reuse concepts. Deliverable D19, AQUAREC project.
[136] Hochstrat et al., 2006. Report on integrated water reuse concepts. Deliverable D19, AQUAREC project
[137] Tsagarakis, K.P., Tsoumanis, P., Chartzoulakis, K., Angelakis A.N., 2001. Water resources status including wastewater treatment and reuse in Greece: Related problems and prospectives. Water International, 26, 2, pp. 252–258
[138] TYPSA, 2012. Wastewater reuse in the European Union. Service contract for the support to the follow-up of the Communication on Water Scarcity and Droughts, Report for DG ENV.
[139] BIO by Deloitte, 2015. Optimising water reuse in the EU, Final report prepared for the European Commission (DG ENV), Part I. In collaboration with ICF and Cranfield University
[140] Eurostat data, Agri-environmental indicators
[141] Kalligaros, D., 2004. *The cost of irrigation water in Greece*, Postgraduate Thesis, Environmental Studies Department, University of the Aegean.
[142] OECD, 2010. *Agricultural Water Pricing: EU and Mexico*, http://www.oecd.org/eu/45015101.pdf
[143] OECD, 2010. *Agricultural Water Pricing: EU and Mexico*, http://www.oecd.org/eu/45015101.pdf
[144] Zotalis, K., Dialynas, E., Mamassis, N., and Angelakis, A.N., 2014. Desalination Technologies: Hellenic Experience, *Water*, *6*, 1134-1150; doi:10.3390/w6051134
[145] Ilias, A., Panoras, A., and Angelakis, A., 2014. Wastewater Recycling in Greece: The Case of Thessaloniki. *Sustainability*, 6, pp. 2876-2892; doi:10.3390/su6052876

Box 1 Case Study 1: Salonica (most populated region of Northern Greece)

The most referenced case study in Greece is that of Salonica[146], where wastewater is treated using activated sludge and chlorination and the secondary effluent of the WWTP is mixed with freshwater from the Axios river at a ratio of 1:5 to keep its quality within the Greek standards. The mixing is essential because the effluent has increased salinity, due to seawater intrusion into the sewerage system.

Experimental and operational use of the treated effluents for irrigation of farms using surface and drip irrigation systems in the neighbouring Chalastra-Kalochori region has provided significant evidence on the associated risks and impacts.

Overall, the evaluation of the results indicates that treated wastewater can be safely used for irrigation without posing a risk to the soils, crops, irrigation systems and human health, provided that the recommended practices are followed. However, only rational use of the effluent and systematic surveillance of the system ensures sustainability and long-term safety.

The reuse scheme in Salonica achieved reductions in use of fertilisers, because of the nutrient content of the treated effluents. The reclaimed water which was applied in rice fields, contained 70-125 kg N/ha and 140-320 kg P/ha. Experiments showed that no additional fertilization was needed to achieve higher yields. The reclaimed water which was applied in fields of corn, cotton and alfalfa contained 17-30 kg N/ha and 35-80 kg P/ha. Conventional fertilization for basic Greek crops is given in the table below. The key assumption is that the use of reclaimed water has reduced the need for fertilization with N and eliminated the need for fertilization with P; however, excessive loads may have been applied, mainly for P. This may have resulted in leaching of nitrates to groundwater bodies and the runoff of P and N to surface water bodies. Generally, irrigation with reclaimed water requires very careful design and monitoring. The transport of nutrients to the water bodies may degrade water quality, reduce biodiversity, cause eutrophication and result in health risks if these water resources are potable. In addition, increased concentration of nutrients, and particularly N, may significantly affect the growth and quality of irrigated crops. It may cause excessive vegetative growth at the expense of crop yield and lower accumulation of carbohydrates in sugarbeets and fruits.

Table 1 Conventional fertilization for various crops in Greece

Crop	Annual conventional fertilization	
	(kg N/ha)	(kg P/ha)
Wheat	131	16
Corn	214	48
Cotton	195	31
Alfalfa	0	46

Source: NAGREF [147]

The volume of reclaimed water used for irrigation in Salonica is reported [148] to range between 1.6-5.0 million m^3/y, which is 2.8-8.7% of the average volume of treated effluents. State-controlled EYATH, which operates the WWTP, charges no tariff to farmers for the reclaimed water it supplies. There is also no contract framing the transaction. It is carried out based on the annual approval of the General Assembly of the local Farmers' Association. The main obstacles which were addressed during the project were related to administrative bureaucracy, reluctance of farmers and lack of public awareness. The establishment of the Greek standards in 2011 and the simplification of licensing in 2013 has partly solved the first issue. The second issue was addressed in practice, as trust, credibility and acceptance were built gradually between the company and the local farmers. It should be highlighted, though, that the economic benefit (free reclaimed water, no fertilization, potentially higher yields) is reported to be the key motivation for the farmers to cooperate. The third issue was partly dealt with through public education campaigns and dissemination activities. Public acceptance and involvement is highlighted as a major issue for any similar project.

Source: Appendix D – case study for Greece

Box 2 Case Study 2: Thessaly (major agricultural region in Central Greece)

The Pinios river basin is a key agricultural area in the region of Thessaly, in Central Greece. It faces severe issues with water scarcity and has been designated as a Nitrate Vulnerable Zone (NVZ). Wastewater reuse was one of the emerging technologies which were studied during the i-adapt project, which was one of the European Commission's Projects to Halt Desertification in Europe. [149]A special study focused on wastewater reuse was conducted for the WWTPs of the 3 largest cities (i.e. Larissa, Karditsa and Trikala), as well as for 5 more WWTPs in the area.

The results show that reusing higher volumes of wastewater will require the construction of suitable storage tanks for the winter effluents, which in turn will increase the cost of the reuse scheme. Since cotton represents half of the irrigated area in the region and, as a non-food crop, gaining public acceptance for the project seems easier, the scenarios examined focused only on the irrigation of cotton farms in the vicinity of the WWTPs. The potential for wastewater reuse is estimated at 25 Mm^3/y (23 Mm^3/y for the 3 big cities) or 2-3% of the total annual irrigation abstraction. The total area which could be irrigated is 61,210 ha (55,950 ha for the 3 big cities).

[146] Ilias, A., Panoras, A., and Angelakis, A., 2014. Wastewater Recycling in Greece: The Case of Thessaloniki. *Sustainability*, 6, pp. 2876-2892; doi:10.3390/su6052876

[147] Makropoulos, C., and M. Mimikou, 2012. A Monograph, Innovative approaches to halt desertification in Pinios: Piloting emerging technologies. i-adapt project, NTUA, Athens.

[148] Soupilas, A., Zambetoglou, K., Chantzi, E., Panoras, A., Papastergiou,F., 2012. Agricultural re-use & reclamation of treated effluents: The experience of the Thessaloniki Wastewater Treatment Plant (Thessaloniki, Greece). IWA Water Wiki. International Water Association.

[149] Makropoulos, C., and M. Mimikou, 2012. A Monograph, Innovative approaches to halt desertification in Pinios: Piloting emerging technologies. i-adapt project, NTUA, Athens

For restricted irrigation of cotton, the upgrade of existing WWTPs would require 0.003-0.019 €/m³. Assuming drip irrigation for cotton fields, this would require the construction of closed pipes and the installation of drip irrigation systems costing 0.045-0.118 €/m³. The construction of storage tanks would require 0.008-0.185 €/m³. An additional cost for monitoring is expected, though not included in the analysis. The total cost of the scheme would range between 0.123 and 0.304 €/m³. The most cost-efficient cases are the 3 big cities: Karditsa (0.123 €/m³), Larissa (0.195 €/m³) and Trikala (0.232 €/m³). If the full cost is internalised, then the reclaimed water will be supplied to the farmers at the above prices. It should be highlighted, though, that a more accurate and integrated approach should also take into account the potential economic benefits for the farmers when using reclaimed water, such as the reduced cost for fertilisers (1.3 €/kg of N which was not applied) and the increased cotton yields (0.540 €/kg of increased cotton harvest, if any). Taking into account both the average price of the irrigation freshwater in the Pinios river basin (0.03 €/m³), none of the above cases seems capable of supplying reclaimed water to farmers at competitive prices. It is interesting, though, that the total cost of irrigation freshwater (including resource and environmental cost) reaches 0.339 €/m³, which is significantly higher than the cost of reclaimed water for irrigation. Raising the price of the irrigation freshwater much higher, to achieve full cost recovery, seems rather a theoretical option. Opposition from farmers would probably block such an approach. Furthermore, a more detailed study is missing on the integrated impacts of a price increase. Integrated modelling work conducted for the Pinios river basin suggests that wastewater reuse for the irrigation of cotton may be an optimal choice for 14 Mm³/y of treated effluents. It has also been estimated that there is a net benefit for the farmers (0.26 €/m³), when considering the total balance of costs and benefits at farm level[150].

Source: Appendix D – case study for Greece

Overall, technical, economic and social reasons will continue to block faster uptake of wastewater reuse for agricultural irrigation in the baseline. Additional wastewater reuse might come from the WWTPs where it is already implemented and potentially from some more new sites in Crete[151]. A conservative estimate is that wastewater reuse in irrigated agriculture would increase by 10-20% up to 2025 (Appendix D- case study for Greece).

Aquifer recharge

In Greece, the average annual groundwater availability for abstraction is reported at 3,550 million m³/year[152]. When considering actual water abstraction in Greece, groundwater resources account for 38% of the total water abstraction. Groundwater is a primary source for drinking water in rural areas and for the industrial sector. It is also a significant source of water for irrigated agriculture, which covers 84% of total water use. Almost 80% of the Greek groundwater bodies are in a good state. Only 17% of them are in bad quantitative state[153].

The reuse of treated urban wastewater for aquifer recharge is differentiated depending on the type of aquifer (potable or non-potable water resources) and the applied method (direct injection in boreholes and wells or surface spreading and infiltration). It should be highlighted that direct injection of reclaimed water is not allowed for aquifers with potable water resources. Additionally, a hydrogeological study is required in all cases.

Reported data on aquifer recharge were not found in Eurostat or in the “National Program for the Management and Protection of Water Resources”[154]. After communication with the Special Secretariat for Water, the Greek authorities could not provide additional information on similar projects. Literature review revealed only two cases of aquifer recharge in Greece. Both were/are conducted in the context of research projects and serve as pilot sites. It is interesting that both of them are actually wastewater reuse projects (see Box 3).

[150] Panagopoulos, Y., Makropoulos, C., Kossida, M., Mimikou, M., 2014. Optimal Implementation of Irrigation Practices: Cost-Effective Desertification Action Plan for the Pinios Basin. Journal of Water Resources Planning and Management, 140 (10).
[151] Agrafioti, E., Diamadopoulos, E., 2012. A strategic plan for reuse of treated municipal wastewater for crop irrigation on the Island of Crete, Agricultural Water Management, 105, 57-64
[152] Eurostat data, Water statistics, Agricultural statistics, Crop statistics, Agri-environmental indicators, Agricultural Census in Greece.
[153] COM, 2015. *WFD implementation report on River Basin Management Plans, MS: Greece*, Commission Staff Working Document accompanying the document Communication from the Commission to the European Parliament and the Council: "The Water Framework Directive (WFD) and the Floods Directive (FD): Actions towards the ‘good status’ of EU water and to reduce flood risks”, European Commission, Brussels.
[154] Koutsoyiannis, D., Andreadakis, A., Mavrodimou, R., Christofides, A., Mamassis, N., Efstratiadis, A., Koukouvinos, A., Karavokiros, G., Kozanis, S., Mamais, D., and Noutsopoulos, K., 2008. *National Program for the Management and Protection of Water Resources*. Support to the development of the national program for the management and conservation of water resources, 748 pages, Department of Water Resources and Environmental Engineering, National Technical University of Athens, Athens.

Box 3 Case Study: Lavrion (coastal aquifer for non-potable water use near Athens) [155,156]
During the MARSOL project (2013-2016) Managed Aquifer Recharge (MAR) is being performed for a coastal, alluvial and karstified aquifer in the area of the Technological Park of Lavrion, which is near Athens. The aquifer is used for non-potable water resources and suffers from sea water intrusion and over-abstraction for irrigation purposes. Reclaimed water from the WWTP of KELM is being transported with vehicles and recharged into the aquifer using surface spreading in infiltration basins. The Soil-Aquifer-Treatment (SAT) system is being employed. No cost data are available for this application.

Source: Appendix D – case study for Greece

For a WWTP of 4,000 m^3/day the estimated cost for aquifer recharge is at least 0.17 €/m^3 to 2.12 €/m^3. When using treatment with microfiltration or reverse osmosis, the cost of electricity could be 0.15 €/m^3. A newer abstraction from the recharged aquifer for indirect use would require an additional cost for pumping. Hence, the whole chain of costs would increase further. On the other hand, wastewater reuse in agricultural irrigation could cost 0.44 €/m^3 [36] (a range of 0.123-0.304 €/m^3 is reported at one of the sites (see Appendix for the Greek case study). Generally there is a lack of concrete economic data, but reuse for aquifer recharge seems to be less mature and less competitive than reuse for agricultural irrigation in Greece.

Overall, very limited expansion is expected for aquifer recharge using reclaimed water under the baseline.

Italy

State of water resources and treated wastewater reuse

Despite an average annual rainfall of 1 000 mm/year, well above the European average, average freshwater availability for the population (2 900 m^3/capita) is one of the lowest among OECD countries, due to high evapotranspiration, rapid run-off and limited storage capacity (OECD, 2013). In addition, available resources are distributed very unevenly across the national territory: 59.1% are in fact in the North, whereas the rest is shared by the Centre (18.2%), the South (18.2%) and the islands (4.5%).

With annual water abstraction making up 31% of available water resources, Italy is classified as a medium-high water-stressed country (OECD, 2013).

Under the Law-decree n. 152, a new legislative set of rules was promulgated on June 12th, 2003 (Ministry Decree, D.M. no 185/03) under which recycled water can be used for (APAT, 2008):

- Irrigation of crops for human and animal consumption, as well as non-food crops. Irrigation of green and sport areas;
- Urban uses: street washing, heating and cooling systems, toilet flushing; and
- Industrial uses: fire control, processing, washing, thermal cycles of industrial processes (recycled water must not get in contact with food, pharmaceutical products or cosmetics).

Treated wastewater is used mainly for agricultural irrigation. However, the controlled reuse of municipal wastewater in agriculture is not yet developed in most Italian regions and has decreased due to the low quality of water.

Average costs, as calculated by ISPRA in a survey of several Italian recycling plants (different plants for different uses: urban, industrial, agriculture) range between 0.083 and 0.48 EUR/m^3. As a comparison, the costs of abstracting water from rivers and groundwater bodies is estimated at 0.015-0.2 EUR/m^3. The high cost of recycled water is generally indicated as one of the main barriers to water reuse[157].

[155] EYDAP, eyadap.gr
[156] MARSOL project, www.marsol.eu
[157] ISPRA, 2009. L’ottimizzazione del servizio di scarico urbane: massimissazione dei recuperi di risorsa (acque e fanghi) e riduzione dei consumi energetici. Rapporto 93/2009. http://www.isprambiente.gov.it/it/pubblicazioni/rapporti/l2019ottimizzazione-del-servizio-di-depurazione

Agricultural irrigation

Nearly 50% of water abstraction is attributed to the agricultural sector.

Irrigated areas are unevenly distributed across the country: 66% of irrigated area is, in fact, concentrated in the relatively water-abundant North, whereas the rest is shared between the Centre (6%) and the South (28%). The three major irrigated crops are maize, rice and vegetables (ISTAT, 2010). Although the irrigated agricultural area only accounts for 19% of the total Utilised Agricultural Area (UAA)(ISTAT, 2010), in terms of production, irrigated agriculture accounts for 50% of total production and 60% of total value added of the agricultural sector, and its products constitute 80% of agricultural exports (Althesys, 2013).

The use of untreated wastewater has been practiced in Italy at least since the beginning of this century, especially on the outskirts of small towns and near Milan. Reuse of untreated wastewater is prohibited in Italy: the legislation requires that all discharges comply with normative standards. Therefore, the reuse of untreated wastewater is illegal and, as such, subject to penal and administrative sanctions. Treated wastewater is used mainly for agricultural irrigation. However, the controlled reuse of municipal wastewater in agriculture is not yet developed in most Italian regions.

Aquifer recharge

Groundwater makes up almost 50% of water abstracted for domestic water supplies (ISTAT, 2012b). Overexploitation has been reported in the North, in the lower reaches of the Po plain and around Venice, due to industrial and agricultural uses as well as gas and oil extraction.

Water availability differs significantly from Northern to Southern Italy. In the North, water is relatively abundant, due to stable and abundant flows in water courses throughout the year. In addition, out of 13 billion m^3 of groundwater available annually, over 70% is located in the North, and particularly in the Po river plain. In contrast, the South of Italy is often subject to long periods without precipitation, resulting in droughts and water rationing (OECD, 2013).

Over 52% of GWBs are assessed as having good quantitative status, according to Italy's reporting; however, the status is unknown for almost 32%.

At present, artificial aquifer recharge interventions are not common in Italy, and current practice focuses mainly on pilot experimental sites (Regione Emilia Romagna, 2008[158]; confirmed by other sources up to 2015,). Existing examples of artificial aquifer recharge are being implemented thanks to EU LIFE and FP7 funding:

- LIFE+ AQUOR (ended in May 15): implementation of artificial aquifer recharge in the Province of Vicenza - http://www.lifeaquor.org/en ;
- LIFE+ TRUST (ended in December 2011): research in the aquifer recharge area in the Veneto plain (rivers Isonzo, Tagliamento, Livenza, Piave, Brenta and Bacchiglione) http://www.lifetrust.it/cms/ ;
- LIFE+ WARBO (ended in March 2015): testing of artificial aquifer recharge methods (from rainwater) in the Po Delta and in the Pordenone province - http://www.warbo-life.eu/it ; and
- MARSOL – FP7 (on-going): Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought – Pilot sites in Italy: Brenta (Veneto) and Serchio (Liguria) - http://www.marsol.eu/6-0-Home.html .

A recent modification to the Environmental Act – Art. 24, comma 1, Law 97/2013 – clarified some important technical and permitting aspects of aquifer recharge. In particular, these interventions can be authorised provided that they are executed in compliance with the criteria to be established by the Ministry of Environment through a specific Decree – Ministerial Decree 2 May 2016, n.100.

According to Legislative Decree 152/06, wastewater discharge into groundwater bodies is forbidden with some exceptions. Such exceptions include artificial aquifer recharge, provided that his does not compromise

[158] http://ambiente.regione.emilia-romagna.it/acque/informazioni/documenti/studio-sulla-ricarica-artificiale-delle-falde-in-emilia-romagna/view

the achievement of the environmental objectives established for the specific groundwater body. Aquifer recharge is established and regulated by the RBMPs and the Water Protection plan.

Artificial aquifer recharge is also subject to Environmental Impact Assessment (LIFE AQUOR, 2015[159]).

Artificial aquifer recharge was also included in the National Operational Programme "Governance and systemic actions – European Social Fund 2007-2013 – Axis E Institutional Capacity, Specific Objective 5.5 Reinforce and Integrate the environmental governance system, Action 7A Horizontal actions for environmental integration", as part of models and tools for water resource management (natural water retention measures, aquifer recharge and participatory systems)[160].

At present, no testing of artificial groundwater recharge with treated effluents has been reported: this practice is forbidden in Italy[161].

Romania

State of water resources and treated wastewater reuse

Romania's water resources are relatively poor and unevenly distributed in time and space with about 40 billion m^3 being available for use per year. Water demand in Romania in 2014 was 7.21 billion m^3/year.

In 2013, the Water Exploitation Index was 15.2 (Eurostat), which is below the EEA's threshold of 20% for water stress[162].

The balance between water availability and the expected trends for water demand shows no deficit at state level or in the 11 sub-basins; there are only a few river sections with deficits in the Prut - Bârlad basin that should be carefully considered in the future[163].

Currently treated wastewater reuse is not being practiced in Romania for either irrigation or aquifer recharge. Wastewater reuse in irrigation was launched experimentally as part of research projects, but it is not a mainstream practice. In regard to aquifer recharge, this is currently a prohibited practice, as the Waters Law prohibits injections of wastewater into groundwater.

Furthermore, given decreasing water consumption, lack of irrigated agriculture and adequate natural recharge of the most aquifers in Romania, there is low demand for the use of treated wastewater overall.

Agricultural irrigation

The total irrigated area in Romania is 2.99 million ha with 85% of the area being irrigated from the River Danube. In reality, (functional) irrigated land accounted for less than 300,000 ha (less than 1% of the total arable land) in the last 5 years (2011-2015), consuming about 1 million m^3 per year.

Although Romanian legislation does not forbid the use of treated wastewater in irrigation, there are no specific regulations and standards that govern water reuse. Additionally, the low number of users that are connected to the irrigation system and the relatively low water volume that is used for irrigations at national level does not currently act as an incentive to invest in further technologies.

In the long run, the interest in treated water reuse for irrigation might increase, as forecasts predict a significant increase of the number of users connected to the irrigation system, while research has begun to study the conditions under which treated wastewater could be used in agriculture at experimental level.

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[159] http://www.lifeaquor.it/file/649-A6_linee_guida_tecnico_operative_I.pdf

[160] http://www.pongas.minambiente.it/pubblicazioni/misura-7a/pubblicazioni/news/studio-di-settore-modelli-e-strumenti-di-gestione-e-conservazione-delle-risorse-idriche-sistemi-naturali-di-ritenzione-idrica-ricarica-artificiale-delle-falde-e-processi-partecipativi

[161] The Ministerial Decree 2 May 2016, n.100 indicates the sources for groundwater recharge, which do not include wastewater.

[162] The water exploitation index (WEI) in a country is the mean annual total demand for freshwater divided by the long-term average freshwater resources. The following threshold values/ranges for the water exploitation index have been used to indicate levels of water stress: (a) non-stressed countries < 10%; (b) low stress 10 to < 20%; (c) stressed 20% to < 40%; and (d) severe water stress ≥ 40%. (EEA, 2015. http://www.eea.europa.eu/data-and-maps/indicators/water-exploitation-index)

[163] Romanian Waters

Aquifer recharge

The groundwater potential in Romania is estimated at 9.6 billion m^3/year. In general terms, groundwater is not overexploited in Romania. In fact, data for 2014 showed that surface water abstraction accounted for around 10 times the volume of water abstracted from groundwater resources.

Furthermore, aquifer recharge using treated wastewater is currently a prohibited practice in Romania with the Waters Law explicitly prohibiting injections of wastewater into groundwater. The current potential for treated wastewater reuse in aquifer recharge, therefore, is effectively non-existent.

D2 Summary of impact assessment

The summary of the anticipated environmental, economic and social impacts in selected Member States are presented in tables below. The selection of the countries illustrates anticipated impacts in Member States with and without existing national wastewater reuse standards (See Appendices C for the approach to the selection and the case studies and this Appendix for the Member States case study reports).

Table D1.5 Synthesis table of impact assessment for agriculture irrigation – non binding

	Spain	France	Italy
Overall economic impact	-/--	0/-	0
Functioning of the internal market and competition	- -	0	0
Operating costs and conduct of business/Small and Medium Enterprises	- -	- -	0
Administrative burdens on businesses	-	-	0
Public authorities	0/-	0	0
Innovation and research	+	+	0
Consumers and households	-	-	0
Overall social impact	0/+	0/+	0
Employment and labour markets	0	0	0
Governance, participation, good administration, access to justice, media and ethics	0/+	0/+	0
Public health and safety	0/+	+	0
Overall environmental impact	0	0	0
Water quality and resources	0	0	0
Renewable or non renewable resources	0	0	0
The environmental consequences of firms and consumers	0	0	

Table D1.6 Synthesis table of impact assessment for agriculture irrigation –binding

	Spain	France	Italy
Overall economic impact	0/-	0/-	+
Functioning of the internal market and competition	0	0	++
Operating costs and conduct of business/Small and Medium Enterprises	-	-	+
Administrative burdens on businesses	- -	- -	-
Public authorities	0	0	+ +
Innovation and research	+	+	0/-
Consumers and households	-	-	+
Overall social impact	+	+	+
Employment and labour markets	0	0	+
Governance, participation, good administration, access to justice, media and ethics	+	+	0
Public health and safety	++	++	++
Overall environmental impact	0/+	0/+	++
Water quality and resources	0/+	0/+	0/+
Renewable or non renewable resources	0	0	++
The environmental consequences of firms and consumers	0/+	0/+	

Table D1.7 Synthesis table of impact assessment for aquifer recharge – non binding

	Spain	France	Italy
Overall economic impact	0/-	0	+
Operating costs and conduct of business/Small and Medium Enterprises	0	0	0/+
Administrative burdens on businesses	0	0	0/+
Public authorities	0	0	0
Innovation and research	0	0	+ +
Consumers and households	0/-	0	0
Overall social impact	0	0	+
Employment and labour markets	0	0	+
Governance, participation, good administration, access to justice, media and ethics	+	0	+
Public health and safety	0	0	0/+
Overall environmental impact	0/+	0	0/+
Water quality and resources	+	0	+
Renewable or non-renewable resources	0	0	0
The environmental consequences of firms and consumers	0	0	0

Table D1.8 Synthesis table of impact assessment for aquifer recharge –binding

	Spain	France	Italy
Overall economic impact	0/-	0/+	0/+
Operating costs and conduct of business/Small and Medium Enterprises	0	0/+	0/+
Administrative burdens on businesses	0	0	0/+
Public authorities	0	0	-
Innovation and research	0	+ +	+ +
Consumers and households	0/-	0/-	0/-
Overall social impact	+	+	+
Employment and labour markets	0	+	+
Governance, participation, good administration, access to justice, media and ethics	++	+	+ +
Public health and safety	0	0/+	+
Overall environmental impact	+	0/+	+
Water quality and resources	++	0/+	+ +
Renewable or non-renewable resources	0	0	0
The environmental consequences of firms and consumers	+	0/+	+

Table D1.9 Environmental, economic and social impacts of adopting non-binding standards for treated wastewater reuse in agricultural irrigation in selected Member States

Category of impacts			
Environmental impacts	**France**	**Romania**	**Spain**
Water quality and resources	Overall, reuse of treated wastewater decreases quantitative pressures on freshwater resources, by giving “a second life” to water. However, this policy option would not promote an expansion of water recycling practices in the country, so no significant changes on current quantitative pressures on freshwater resources can be expected.	The option would contribute to towards improved quality of freshwater resources as a result of additional treatment that would be required to comply with the minimum water quality requirements.	Overall, water recycling decreases quantitative pressures on freshwater resources, including groundwater. However, it does not seem that this policy option will promote an expansion of water recycling practices in the country, so no significant changes on current qualitative pressures on freshwater resources can be expected
Renewable or non-renewable resources	No significant impacts are anticipated.	No significant impacts are anticipated as the option is not likely to significantly affect renewable or non-renewable resources. The amount of treated wastewater used for irrigation is not anticipated to increase as a result of adoption of this option.	No significant impacts are expected.
The environmental consequences on firms and consumers	Irrigating crops with recycled water is in principle an environmentally friendly practice, as it saves freshwater resources that can be diverted to other uses (e.g. domestic) or to the environment. However, this policy option would not promote an expansion of water recycling practices in the country, so no significant impact is expected on current levels of agricultural production with recycled water.	Products irrigated with treated wastewater might become more expensive, due to increased costs of production as a result of additional investment in more advanced wastewater treatment processes.	Irrigating crops with recycled water is in principle an environmental-friendly practice, as it spares freshwater resources which can be diverted to other uses (e.g. domestic) or to the environment. However, it does not seem that this policy option will promote an expansion of water recycling practices in the country, so no significant impact is expected on current levels of agricultural production with recycled water.
Economic impacts	**France**	**Romania**	**Spain**
Functioning of the internal market and competition	No relevant impacts are expected.	Adoption of non-binding standards might create some disturbances in the functioning of the competition, both to water suppliers and farmers, since some of them may pledge to respect the standards and make investments in this direction, while others may not.	Relevant impacts on competitiveness might be expected if operators are encouraged to upgrade their treatment units to comply with lower thresholds of quality parameters (TSS, turbidity and BOD_5) while keeping in a more intensive monitoring programme than in other MS. However, it is still unclear whether new monitoring requirements (especially frequency) will be stricter or easier to be attained by water operators
Operating costs and conduct of business/Small and Medium Enterprises	As standards would be non-binding, national parameters might not be adjusted to EU parameters. Whether costs would arise is unknown at present and will depend on technologies currently in use at specific wastewater treatment plants.	Depending on the price of treated wastewater, adoption of such a non-binding instrument might have a limited applicability in the country, since the majority of Romanian farmers are unable to afford irrigation at current water prices, let alone at the increased prices associated with treated wastewater reuse. The situation may change in the future as forecasts predict a rapid development of agriculture in Romania with climate change exacerbating droughts in some regions, making irrigation a necessity.	Existing reclamation plants would be encouraged to upgrade their treatment units to comply with lower thresholds of quality parameters (TSS, turbidity and BOD_5), and this would imply additional costs. However, it is not possible to estimate these costs given the large range of costs showed for different technologies currently in use and some lack of data.

Category of impacts			
	This policy option includes more stringent limits for some of the quality parameters. Assuming no change to other national requirements (e.g. monitoring protocols, requirements for pipelines, etc.), this policy option would introduce additional constraints to the development of wastewater reuse for irrigation purposes in France. Nevertheless, as this case considers non-binding requirements there would be no obligation for France to adjust to EU standards, so policy makers might decide not to adjust them –and, in this case, the above mentioned additional constraints would not occur.	Water suppliers would face additional investments in wastewater treatment and increased sampling costs in order to comply with the requirements (if non-binding standards were to be adopted in Romania) while dealing with uncertain demand for the treated wastewater from the farmers.	The current Spanish regulation already requires operators to comply with a complete monitoring programme. This policy option includes stricter limits on some parameters, and it is assumed that other requirements will not change (e.g. monitoring protocols, requirements for pipelines, etc.). Therefore, it can be assumed that this policy option might even be (slightly) more constraining for the development of the water reuse sector for irrigation purposes in Spain.
Administrative burdens on businesses	Higher quality standards on three parameters might require existing WWTPs supplying treated wastewater for use to submit an application to adjust their permit to new requirements (water reuse must be permitted through an Arrêté préfectoral). This might imply additional administrative costs for water companies. No additional monitoring costs are anticipated, as the same parameters would need to be monitored at the same frequency as compared to the current situation.	While the likelihood of additional administrative burdens on businesses is low, in some situations (e.g. for some types of crops, water suppliers from a heavily polluted region etc.) administrative burdens might increase on a case by case basis.	The upgrade of treatment units to adapt them to higher quality standards might require additional effort applying for complementary authorisations, with additional administrative costs for water reclamation companies. No additional monitoring costs are expected, as the same parameters will need to be monitored, and with the same frequency –as compared to the current situation.
Public authorities	No significant impact is anticipated on budgets of public authorities. As mentioned above, relatively more stringent limits on some quality parameters might require water companies to submit an application to adjust their current permits, and this might involve some administrative costs for public authorities in charge of issuing permits. However, at present very few wastewater treatment plants in the country supply treated wastewater for reuse, so the overall impact is not expected to be significant. Furthermore, the current system (quality categories, quality parameters) would not change in terms of its conceptual design, so upgrading the limits on some parameters would not require significant administrative adjustments.	Public authorities will have the responsibility to adapt and adopt the non-binding standards to the Romanian context. Since the Ministry of Environment, Waters and Forests currently does not see the adoption of such standards as an absolute necessity, this might delay or prevent their adoption.	No significant impact is expected on budgets of public authorities. Complementary authorisations might involve some administrative costs for public authorities in charge of issuing permits. There might be additional costs of explaining operators the new scenario.
Innovation and research	The introduction of stricter limits for some quality parameters might promote research on innovative treatment technologies.	The non-binding standards would come to the assistance of the research community which showed some interest in this technical possibility (http://www.icpe.ro/ro/p/siera_2016_ro	Encouraging the adoption of stricter limits for some quality parameters might promote research on innovative treatment technologies.

Category of impacts			
Consumers and households	Additional costs for WWTPs might result in increased costs to water users. Additional costs might be charged on farmers potentially providing a disincentive to use treated wastewater for irrigation. Alternatively, additional costs might be recovered through cross-subsidization mechanisms, i.e. with prices of treated wastewater kept low in order to provide an incentive for its use. This might result in other users (often domestic users) cross-subsidizing use. On the other hand, adoption of relatively more stringent water quality requirements might result in increased levels of consumer protection.	Introduction of non-binding standards in wastewater reuse would have an impact on the price of agricultural and food products. Issues related to the quality of irrigation water, and subsequently any actual or perceived risks to the quality of agricultural and food products might also be of concern to consumers (especially since no wastewater reuse is currently taking place in agricultural irrigation). Consumers may be sceptical of this new practice and this would need to be managed through dedicated communication and awareness raising activities.	Additional costs for water reclamation plants might also imply increased costs for water users. Additional costs might be charged on farmers: however, an increase in irrigation water price might provide a negative incentive to the use of recycled water in irrigation. Alternatively, as it often happens, additional costs might recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with available data and information. On the other hand, stricter quality limits might increase consumer protection and acceptance.
Social impacts	**France**	**Romania**	**Spain**
Employment and labour markets	The policy option would promote research on innovative technologies potentially resulting in creation of jobs. It is not possible to quantify this impact; however, it is not expected to be significant, especially considering that this policy option is not expected to promote a wider adoption of water recycling for irrigation in France.	The introduction of wastewater reuse standards might create new jobs in wastewater treatment and innovation and research sectors.	In case the policy option will promote research on innovative technologies, some jobs might be created, depending on the level of adoption of the recommendations.
Governance, participation, good administration, access to justice, media and ethics	Stricter water quality requirements might increase consumer protection.	Adoption of minimum water quality requirements would contribute to consumer protection ensuring appropriate quality of treated wastewater used for irrigation and of agricultural products on the market.	Stricter quality limits might increase consumer protection.
Public health and safety	The current French regulation is very restrictive, and this is motivated by current uncertainties on the actual health impact of water recycling for irrigation. Therefore, it can be expected that the current national legislation is already protecting the population against possible risks. Nevertheless, this policy option proposes even stricter quality standards for treated wastewater, and is expected to increase the level of health protection of such practices.	Non-binding of minimum water quality requirements would ensure protection of the human health and safety of individuals/populations. The option would also decrease the likelihood of health risks due to exposure to dangerous substances.	The current Spanish regulation is already protecting the population against the possible risks. Nevertheless, this policy option proposes even stricter quality standards for recycled water, so, depending on the level of adoption, it might be expected to increase the level of health protection of these practices.

Table D1.10 Environmental, economic and social impacts of adopting legally binding standards for treated wastewater reuse in agricultural irrigation in selected Member States

Environmental impacts	Cyprus	Greece	France	Italy	Romania	Spain
Water quality and resources	The option would result in reduced pressure on water resources. It would also provide a positive contribution to the quality of water resources (e.g. reduced impact of waste water discharge on sensitive rivers, reduced risk of saline intrusion in over-exploited coastal aquifers). The impact on soil would depend on the quality parameters considered in the requirements: while the presence of some nutrients and organic matter in treated wastewater can be beneficial to enhance soil fertility and crop production, the presence of other elements (e.g. salts, micro-pollutants) may be detrimental, as well as impacting on the wider environment. In general terms, reuse of treated wastewater for irrigation can decrease the level of purification/treatment necessary for discharge and thus reduce energy consumption and costs associated with water treatment. Non-potable water reuse schemes may have lower energy intensities than other water sources, particularly when compared with desalination. This may have knock-on effects, such as lower overall greenhouse gas emissions		Overall, water recycling decreases quantitative pressures on freshwater resources, by giving "a second life" to water. At this stage, it is unclear whether the standards considered in the IA would further constrain or promote water reuse practices in France.	Water reuse for irrigation would reduce the need for freshwater abstraction, and it would release the pressures on domestic water supply during scarcity periods. In some regions, and especially in the South, seasonal water scarcity often threatens domestic water supply, which is normally given priority over agricultural irrigation The same can be said for coastal areas during the seasonal tourism peak; in addition, it must be noted that the peak is usually in summer, which is the driest season if the year.	The option would contribute to towards improved quality of freshwater resources as a result of additional treatment.	Overall, water recycling decreases quantitative pressures on freshwater resources, including groundwater. At this stage, it is unclear whether the draft JRC proposal will further constrain or promote water reuse practices in the country, so it is not possible to infer whether quantitative pressures on freshwater resources will decrease. If it does, significant impacts are expected especially in those RBD where there is a need to improve water security (e.g. SE of Spain or islands).
Renewable or non-renewable resources			No significant impacts are expected.	In water-scarce regions, large scale adoption of water recycling might potentially cause the expansion of irrigated agriculture, which is now constrained by water availability.	The option does not significantly affect renewable or non-renewable resources, since the amount of water used for irrigation does not increase by adopting this option.	No significant impacts are expected.
The environmental consequences on firms and consumers			Irrigating crops with recycled water is in principle an environmental-friendly practice, as it spares freshwater resources which can be diverted to other uses (e.g. domestic) or to the environment. At this stage, it is unclear whether the standards considered in the	Irrigating crops with recycled water is in principle an environmental-friendly practice, as it spares freshwater resources which can be diverted to other uses (e.g. domestic) or to the environment.	Products irrigated with treated wastewater might become more expensive, due to increased costs of production as a result of additional investment in more advanced wastewater treatment processes	Irrigating crops with recycled water is in principle an environmental-friendly practice, as it spares freshwater resources which can be diverted to other uses (e.g. domestic) or to the environment.

Environmental impacts	**Cyprus**	**Greece**	**France**	**Italy**	**Romania**	**Spain**
			IA would further constrain or promote water reuse practices in France.			At this stage, it is unclear whether the draft JRC proposal will further constrain or promote water reuse practices in the country, so it is not possible to figure out the potential impact on current levels of agricultural production with recycled water.
Economic impacts	Cyprus	**Greece**	**France**	**Italy**	**Romania**	
Functioning of the internal market and competition	The agricultural sector and the food industry, which highly depend on water supply, would increase their resilience against water scarcity, droughts and climate change	The agricultural sector and the food industry, which highly depend on water supply, would increase their resilience against water scarcity, droughts and climate change.	No relevant impacts are expected –as the regulations would equally apply to all water reclamation operators.	With the current regulation, water recycling is only viable for large wastewater treatment plants. With the standards considered in the IA being much less stringent than existing ones, water recycling might become viable for all/more existing treatment plants (both municipal and private plants), or at least for a larger share of existing operators. Thus, this policy option would help in widening the access to water reuse technologies and practices and would promote their adoption.	Adoption of minimum mandatory standards across the EU would allow for an informed and safe consumer choice, with positive impact of the internal market.	No relevant impacts are expected –as the regulations would equally apply to all water reclamation operators
Operating costs and conduct of business/Small and Medium Enterprises	Impacts on SMEs are expected to be positive as they would benefit from an increased and/or better secured access to water. Agricultural businesses, which are the largest consumer of	The avoided cost of future damages is a benefit for the agricultural and food industry sectors. Less stringent water quality requirements (if adopted) would reduce treatment costs. Since the highest share of the	Existing reclamation plants might need to upgrade their treatment units to comply with lower thresholds for quality parameters (TSS, E. Coli), as well as additional quality standards (turbidity, BOD); this would imply additional costs. However, it is not possible to estimate a magnitude of these costs – it	Currently, the costs of adjusting existing treatment plants to comply with water reuse legislation are very high, and this is linked to the very stringent quality standards which must be attained. The introduction of the standards considered in	Water suppliers and farmers that that choose to irrigate using treated wastewater would be affected by higher initial investments in additional wastewater treatment, which might lead to a lack of demand for reused wastewater from the farmers who are often SMEs. This issue is particularly sensitive as most Romanian farmers do not use irrigation at all and further increases in	Existing reclamation plants would need to upgrade their treatment units to comply with lower thresholds of quality parameters (TSS, turbidity and BOD_5), as well as additional quality standards (TSS, turbidity and

Environmental impacts	Cyprus	Greece	France	Italy	Romania	Spain
	freshwater in Cyprus, are likely to be particularly influenced	total cost is associated with infrastructure, the reduction in current costs would be limited. The water industry is expected to benefit, as reuse technologies represent a significant area for further innovation. Impacts on SMEs are expected to be positive as they would benefit from an increased and/or better secured access to water. Agricultural businesses, which are the largest consumer of freshwater in Greece, are likely to be particularly influenced.	will depend on technologies currently in use. These costs might be higher as compared to Ag2. Some representatives of the water sector argue that French regulation currently in force might pose a strong barrier to a wider adoption of wastewater reuse systems in irrigation due to its stringency, making it difficult for operators to comply with monitoring and distribution network requirements The Regulation is in fact thought to be very strict, and it is difficult for operators to comply with monitoring requirements, requirements for the pipeline network, etc.[164]. In the proposed EU approach, quality parameters are stricter, but it is unclear whether monitoring requirements (especially frequency) and requirements for the pipeline network would be stricter or easier to be attained by water operators. It is possible that while different, the same technical requirements and treatment would be used to meet the values. Therefore, it is not possible to infer whether the proposed EU approach would be more or less constraining for water reuse operators. However, the technical prescriptions would be the same, so there should be no significant impact on operating costs in this respect.	the IA is likely to reduce the costs of adapting current wastewater treatment plants to water reuse practices potentially resulting in a reduced costs of irrigation water supply to farmer holdings. However, this must be coupled with risk considerations. Currently, stringent national standards minimize risks, and this might not be the case with less stringent EU requirements. If the latter are adopted, there might be additional costs to manage possible risks, which would counterbalance the reduction of current costs to adjust to existing requirements. In addition, differentiating water quality levels based on final use (types of crops) might not be feasible in Italy. Irrigation is in fact largely managed through Irrigation Consortia, which serve a great number of farms and agricultural area of thousands of hectares, with many crops types (often including the four categories considered for the IA), which means that, in practice, for operational and	prices would push them even further away from connecting to the irrigation system. The same issue of costs might act as a barrier to water operators that are treating wastewater. In particular, water industry operators might be reluctant to invest in technologies and incur additional sampling / testing costs associated with wastewater treatment given the uncertainty about the demand for treated wastewater in irrigation (due to the higher price of water supply). The situation, however, might change in the future as more farmers would be getting access to irrigation system (driven by forecasted expansion of the agriculture sector and increased instances of droughts).	BOD_5); this would imply additional costs. However, it is not possible to estimate a magnitude of these costs given the large range of costs showed for different technologies currently in use and several data gaps. Nevertheless, these costs might be higher as compared to the non-binding option. Whether new monitoring requirements (especially frequency) and requirements for the pipeline network will be stricter or easier to be attained by water operators is still to be defined.

164 Same as above.

Environmental impacts	Cyprus	Greece	France	Italy	Romania	Spain
				management reasons, the strictest standards in the reused wastewater shall be met.		
Administrative burdens on businesses	Given the different conceptual structure of the proposed framework versus the current Cypriot standards and conceptual innovations it introduces, the additional effort by administrations is expected to be high. Given the complexity of the proposed framework administrative burden on national authorities and beneficiaries of wastewater reuse projects will be neutral or negative. However, the increased consistency across the EU is expected to result in a reduction of the administrative burden	Given the different conceptual structure of the proposed framework versus the current Greek framework and the conceptual innovations it introduces, the additional effort by administrations is expected to be high. Given the complexity of the proposed framework the administrative burden for national developers and beneficiaries of water reuse projects will be neutral or negative. However, the increased consistency across the EU is expected to result in a reduction of the administrative burden.	Higher quality standards, as well as additional standards might require that existing water reclamation plant submit an application to adjusting their permit to the new regulation (water reuse must be permitted through an Arrêté préfectoral). This might imply additional administrative costs for water reclamation companies. Additional monitoring costs can be expected, as additional parameters need to be monitored. In addition, measuring BOD levels is much more time-consuming than measuring COD levels, and this also implies additional costs. However, this cannot be nothing more than a hypothesis, as a lot depends on the required monitoring frequency (which at present is unknown).	As compared to the current situation, the introduction of the standards considered in the IA would reduce the costs currently borne by wastewater treatment operators, and in particular: (i) the costs of applying for a water reuse licence; (ii) monitoring and reporting costs: only four parameters should be monitored and reported, against the 55 parameters that must be monitored at present. On the other hand, the definition of four quality categories (depending on the final use of recycled water) might slightly complicate the application procedure, as the final use of recycled water should be well documented.	Depending on the requirements of the standard (the type of data required, reporting frequency, the complexity of submission process), it is likely that both farmers and water suppliers would experience increased administrative burdens for the monitoring and evaluation purposes. This might trigger additional costs (e.g. new staff, new expertise required).	The upgrade of treatment units to adapt them to higher quality standards would require additional effort applying for complementary authorisations, with additional administrative costs for water reclamation companies. Whether new monitoring requirements (especially frequency) will be stricter or easier to be attained by water operators is still to be defined.
Public authorities			No significant impact is expected on budgets of public authorities. As mentioned above, stricter limits on some parameters might require water reclamation companies to submit an application to adjust their current permits, and this might involve some administrative costs for public authorities in charge of issuing permits. However, at present very little water	The costs of completely changing the existing legislation and regulation on water recycling could be significant. As significant might be the costs of adjusting the current enforcement and governance structure to the new parameters. This would occur, in particular, because of the switch between the current system (with no	Public authorities would have the responsibility to adapt and adopt the binding standards to the Romanian context. Since the Ministry of Environment, Waters and Forests currently does not see the adoption of such standards as absolute necessity, this might delay their adoption / implementation. The task might also create some technical problems with adoption since knowledge and experience on treated water reuse is missing.	No significant impact is expected on budgets of public authorities. Complementary authorisations would involve some administrative costs for public authorities in charge of issuing permits. There would be additional costs of

Environmental impacts	Cyprus	Greece	France	Italy	Romania	Spain
			reclamation plant exist in the country, so the overall impact would not be significant. In addition, the standards considered in the IA establishes the same quality categories established by the French system, and the two approaches have some quality parameters in common (although some thresholds are different). Thus, upgrading the regulation should not imply a significant administrative burden.	quality categories) and the proposed EU systems, which distinguishes four quality categories depending on the final use of water. On the other hand, the administrative costs of enforcement and compliance checking are expected to decrease: in fact, only four parameters should be checked and reported against the 55 parameters currently monitored; as a consequence, authorities in charge of enforcement and control should only check 4 parameters at once – thus the overall control procedure should be much faster.	Monitoring and evaluation would also create additional burdens and costs for public authorities. It is possible that new departments would be created and / or new staff hired at the level of some authorities (e.g. National Administration Romanian Waters, County Departments of Agriculture).	explaining operators the new scenario.
Innovation and research	Impacts on competitiveness and innovation are expected to be positive as removal of present barriers to investment is anticipated. A clear and consistent EU framework would allow economies of scale and standardization. This in turn would support innovation and development of solutions at lower costs Considering that water reuse is an emerging worldwide market, a greater	Impacts on competitiveness and innovation are expected to be positive as removal of present barriers to investments is anticipated. A clear and consistent EU framework would allow economies of scale and standardization. This in turn would support innovation and development of solutions at lower costs Considering that water reuse is an emerging worldwide	The introduction of stricter limits for some quality parameters might promote research on innovative treatment technologies. It must be noted, however, that high levels of research and innovation in water reuse have already occurred in the country (for example, in treatment systems and monitoring systems for E. Coli).	The introduction of the standards considered in the IA for water reuse would promote the uptake of water reuse technologies and practices, as it would remove some of the current barriers linked to the existing stringent regulation. Smaller municipal and private plants might also be able to adopt water reuse practices, and this might promote research and innovation. EU common standards might increase public acceptance of agricultural products irrigated with reused	Application of binding standards would be a boost for the research community which already showed some interest in this technical possibility (i.e. http://www.icpe.ro/ro/p/siera_2016_ro)	The introduction of stricter limits for some quality parameters might promote research on innovative treatment technologies.

Environmental impacts	Cyprus	Greece	France	Italy	Romania	Spain
	uptake of reuse at the EU level would provide a showcase for the relevance of these technologies and skills of EU companies towards potential customers in third countries.	market, a greater uptake of reuse at the EU level would provide a showcase for the relevance of these technologies and skills of EU companies towards potential customers in third countries.		wastewater. However, this might not be the case if monitoring will be limited only to a few parameters (as established by JRC standards).		
Consumers and households	The trade of agricultural goods irrigated with reclaimed water would be positively influenced		Additional costs for water reclamation plants might imply increased costs to water users. Additional costs might be charged on farmers: however, an increase in irrigation water price might provide a negative incentive to the use of recycled water in irrigation. Alternatively, as often happens, additional costs might recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with the available data and information. On the other hand, adjusting national standards to EU standards might have a positive impact on the general public perception of using recycled water for irrigation, as it might serve as a further guarantee of the overall safety of the system– in any case, consumer are currently not aware of	A wider adoption of water recycling technologies might imply increased costs for water users. Additional costs might be charged to farmers: however, an increase in irrigation water price might provide a negative incentive to the use of recycled water in irrigation. Alternatively, as often happens, additional costs might recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with the available data and information.	Introduction of standards in water reuse is expected to have an impact on the price of agricultural and food products, since meeting those standards would require additional investment by water suppliers. Issues related to the quality of irrigation water and, subsequently, the quality of agricultural and food products pose a concern to consumers (particularly as treated wastewater is not reused in irrigation at present). Consumers might be sceptical of this new practice and this would need to be managed through dedicated communication and awareness raising activities.	Additional costs for water reclamation plants might also imply increased costs for water users. Additional costs might be charged on farmers: however, an increase in irrigation water price might provide a negative incentive to the use of recycled water in irrigation. Alternatively, as it often happens, additional costs might recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with available data and information. On the other hand, adjusting national

Environmental impacts	Cyprus	Greece	France	Italy	Romania	Spain
			whether the vegetables they buy were irrigated with conventional water or recycled water. . Stricter quality limits and additional parameter to be monitored might increase consumer protection although current quality requirements are already considered more than sufficient to protect consumers' health. .			standards to EU standards might have a positive impact on the public perception of using recycled water for irrigation, as it might serve as a further guarantee of the overall safety of the system. Stricter quality limits might increase consumer protection and acceptance.
Social impacts		**Greece**	**France**	**Italy**	**Romania**	**Spain**
Employment and labour markets	The establishment of an EU framework together with improved communication on actual risks and benefits of water reuse is expected to have a positive impact on confidence of the general public in the quality of the reused water and, therefore, on acceptance of water reuse as a water management tool	More jobs would be created in the water and the agri-food industry. Other sectors are expected to be influenced indirectly. Data available suggests that investments in wastewater reuse have a growth and employment multiplier of 3.5[165] providing a positive contribution for employment.	If the policy option would promote research on innovative technologies, some jobs might be created. It is not possible to quantify this impact, particularly because, at this stage, it is not possible to infer whether the standards considered in the IA approach would promote or further constrain the development of water recycling for irrigation purposes.	A wider adoption of water reuse practices might create new jobs in the sector. However, it is not possible to estimate the potential magnitude of this impact.	The introduction of water reuse standards might create new jobs in water treatment and innovation and research sectors.	In case the policy option will promote research on innovative technologies, some jobs might be created. It is not possible to quantify this impact, especially because, at this stage, it is not possible to infer whether the draft JRC proposal will promote or further constrain the development of water recycling for irrigation purposes.
Governance, participation, good administration, access to justice, media and ethics		The establishment of an EU framework together with improved communication on actual risks and benefits of water reuse is expected to have a positive impact on confidence of the general public in the	Adjusting national standards to EU standards might have a positive impact on the public perception of using recycled water for irrigation, as it might serve as a further guarantee of the overall safety of the system. Stricter quality limits and additional parameter to be monitored might increase consumer protection.	Adjusting national standards to EU standards might have a positive impact on the public perception of using recycled water for irrigation, as it might serve as a further guarantee of the overall safety of the system even though the quality	Adoption of minimum water quality requirements would contribute to consumer protection ensuring appropriate quality of treated wastewater used for irrigation and of agricultural products on the market.	Adjusting national standards to the draft JRC proposal might have a positive impact on the public perception of using recycled water for irrigation, as it might serve as a further guarantee of the overall safety of the system. Stricter quality

165 Processed data by the authors

Environmental impacts	Cyprus	Greece	France	Italy	Romania	Spain
		quality of the reused water and, therefore, on acceptance of water reuse as a water management tool.	In contrast, stricter quality limits might encounter farmers' opposition.	requirements are less strict than they are now. In addition, only a few (four) parameters must be measured and reported, and this can facilitate the communication to common citizens, as well as their understanding of water quality information –at present, only a specialist can go through the 55 quality parameters and fully understand what their mean in terms of quality.		limits might increase consumer protection.
Public health and safety			The current French regulation is considered to be very restrictive, and this is motivated by current uncertainties on the actual health impact of water recycling for irrigation. Therefore, it can be expected that the current national legislation is already protecting the population against the possible risks.	The considered EU intervention includes much less stringent quality requirements as compared to the current national regulation. Adjusting to EU standards would inevitably result in a lower quality of water reused in irrigation (when expressed in terms of certain parameters). However, the standards considered in the IA were developed to protect the health of EU citizens, so negative health impacts are expected to be minimal.	Adoption of minimum water quality requirements would ensure protection of the human health and safety of individuals/populations The option would also decrease the likelihood of health risks due to substances harmful to the natural environment. Romania has very little experience with wastewater reuse in irrigation, making the role of monitoring and evaluation activities even more important to safeguard the quality of delivered treated wastewater and mitigate the likelihood of accidents or mishandling of the treated wastewater.	The current Spanish regulation is already protecting the population against the possible risks. Nevertheless, this policy option proposes even stricter quality standards for recycled water, so it is expected to increase the level of health protection of these practices.

Table D1.11 Environmental, economic and social impacts of adopting non-binding standards for aquifer recharge in Italy, Romania and Spain

Overview of impacts	Italy	Romania	Spain
Environmental impacts			
Water quality and resources	This option is expected to promote research and pilot testing, so some quantitative improvements to the status of groundwater bodies may be expected at the local level.	The option does not significantly decrease or increase the quality or quantity of freshwater and groundwater, unless the requirements of the standard are lower / higher that the water that naturally recharges aquifers at present (surface and rainwater).	Although it does not seem that this policy option will promote an expansion of water recycling practices in the country, the incorporation of an additional control parameter (active substances in pesticides) will have a significant positive impact. The magnitude will depend on the level of adoption of the recommendations
Renewable or non-renewable resources		The option does not significantly affect renewable or non-renewable resources, unless the requirements of the standard are lower / higher than those of the waters that naturally recharge aquifers at present.	No significant impacts are expected.
The environmental consequences on firms and consumers	No relevant impact is expected.	The option may lead to more sustainable groundwater use.	No significant impacts are expected.
Economic impacts			
Operating costs and conduct of business/Small and Medium Enterprises	This option is expected to promote aquifer recharge with treated effluent only at the experimental level. It can be expected that research and pilot testing would be conducted by public institutions with the participation of private institutions financed by public funding (e.g. LIFE, Horizon 2020 funding as is happening today, as well as national funds). So no relevant impact can be expected on operating costs and conduct of private businesses. However, it is expected to bring about new research and funding opportunities.	Application of non-binding standards could increase the costs to water suppliers, since wastewater would need to be additionally treated to ensure the required quality. This would involve further investments, costs of sampling and testing, etc. However, given the legally non-binding nature of the requirements no significant uptake (and associated costs) is anticipated.	Existing reclamation plants would be encouraged to upgrade their monitoring procedures to control for active substances in pesticides, and this would imply additional costs. However, it is not possible to estimate a magnitude of these costs given the large range of costs showed for different technologies currently in use. The current Spanish regulation already requires operators to comply with a complete monitoring programme.
Administrative burdens on businesses	Under this option, aquifer recharge with treated effluents is expected to be applied only at the pilot testing/ research level, so no additional administrative burdens on businesses are expected. The option is however expected to bring about new research and funding opportunities.	The administrative burdens would increase, since the national authority in charge of water resource management (National Administration Romanian Waters) would require additional monitoring data on treated wastewater. This would act as a burden on suppliers of treated wastewater. However, given the legally non-binding nature of the requirements no significant uptake (and associated administrative burdens) are anticipated.	No significant impact is expected due to the voluntary incorporation of an additional control parameter (active substances in pesticides) as compared to the current situation.

Overview of impacts	Italy	Romania	Spain
Environmental impacts			
Public authorities	This option is mainly expected to promote research on aquifer recharge with treated effluents, so no additional burden for public authorities is expected. Public authorities can decide to invest in research and pilot projects, but this would be a voluntary budget allocation decision (potentially compensated by the benefits of new knowledge) and cannot be considered as a negative impact.	Public authorities would have the responsibility to adapt and adopt the non-binding standards to the Romanian context. Adoption of standards cannot be done without lifting the prohibition to discharge wastewater into groundwater. The expected low support from the Ministry of Environment, Waters and Forests in the adoption of these standards would also act as a barrier. Implementation might also create some technical problems, since knowledge and experience on treated water reuse is missing. However, given the legally non-binding nature of the requirements no significant uptake (and associated impacts on public authorities) are anticipated.	No significant impact is expected on budgets of public authorities. There might be additional costs of explaining operators the new scenario.
Innovation and research	This option is expected to positively promote research and innovation in aquifer recharge with treated effluents.	The non-binding standards would come to the assistance of the research community (i.e. http://www.icpe.ro/ro/p/siera_2016_ro), although there is no evidence that the subject of wastewater reuse for aquifer recharge had been so far approached by Romanian research institutes.	No significant impact is expected due to the voluntary incorporation of an additional control parameter (active substances in pesticides) as compared to the current situation.
Consumers and households	This option is mainly expected to promote research on aquifer recharge with treated effluents, so no relevant impact on consumers and households are expected.	In the case of uptake, consumers might be affected by increased prices of water. Issues related to the quality of water might also be of concern for consumers, especially since currently aquifers are not recharged with treated wastewater.	Additional costs for water reclamation plants might imply increased costs for water users. Alternatively, as it often happens, additional costs might recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with available data and information.
Social impacts			
Employment and labour markets	The promotion of research and innovation on treatment technologies for aquifer recharge might increase the demand for qualified technical and scientific personnel. Background studies on the introduction of this technology in Italy might involve contributions from private consultancies or national universities and research institutes. However, it is very difficult to infer something more than qualitative about the possible impact on the labour	Promotion of water reuse for aquifer recharge in Romania might increase demand for technical and scientific personnel and create new jobs in water treatment and innovation and research.	No significant impact is expected due to the voluntary incorporation of an additional control parameter (active substances in pesticides) as compared to the current situation.

Overview of impacts	Italy	Romania	Spain
Environmental impacts			
	market. It can reasonably be expected that water recycling for aquifer recharge would be a niche sector under this option, so the macro-economic impact would be very limited (both in case of research and development of the topic that in case of future adoption of this practice).		
Governance, participation, good administration, access to justice, media and ethics	The development of EU standards, as well as the consequent promotion of research and innovation in the country, might bring the practice to the attention of the general public. In addition, the existence of EU standards, albeit non-binding, could positively steer public perception and acceptance of this practice.	Promotion of minimum water quality standards for aquifer recharge across the EU would ensure consistent levels of consumer protection and would result in increased awareness about the quality of water being used.	Enhanced water security would have a positive impact, although it depends on whether the adoption of recommendations at the EU-level would promote or not the development of aquifer recharge by reclaimed water.
Public health and safety	Research and pilot testing might improve existing technologies, also in terms of safety and thus public health.	Since the standards are non-binding anticipated impact on public health and safety is difficult to ascertain.	The current Spanish regulation is already protecting the population against the possible risks.

Table D1.12 Environmental, economic and social impacts of adopting legally binding standards for aquifer recharge in selected Member States

Category of impacts					
Environmental impacts	**Cyprus**	**France**	**Italy**	**Romania**	**Spain**
Water quality and resources	The adoption of wastewater reuse is already high in Cyprus and is likely to increase resulting in a reduced pressure on water resources. There would also be a positive contribution to the quality of water resources as a result of a reduced risk of saline intrusion in over-exploited coastal aquifers	As the option is mainly expected to relaunch discussions in the country (rather than stimulate aquifer recharge), no relevant impact is anticipated on water quality and resources. Even if the practice were to become legal (in the long term), quality standards are expected to be very stringent, so no negative qualitative impact can reasonably be expected.	The uptake of aquifer recharge with treated effluents techniques can significantly contribute to current qualitative and overexploitation issues affecting groundwater bodies – and this is especially true in Southern regions. However, at the moment it is not possible to infer an estimate of the level of uptake of this practice across the national territory, so it is not possible to provide an	The option does not significantly decrease or increase the quality or quantity of freshwater and groundwater, unless the requirements of the standard are lower / higher that the water that naturally recharges aquifers at present (surface and rainwater).	The mandatory incorporation of an additional control parameter (active substances in pesticides) will have a significant positive impact, especially in those RBD where there is a need to improve water security (e.g. SE of Spain or islands).

Category of impacts					
Environmental impacts	**Cyprus**	**France**	**Italy**	**Romania**	**Spain**
		From a quantitative point of view, it must be recalled that the practice is unlikely to be widely adopted in France because the country is generally rich in water resources –among other reasons. However, the adoption of this practice on groundwater bodies with mediocre quantitative status might positively contribute to improving water resources.	indication of the magnitude of the positive impact on groundwater resources –the larger the uptake, the larger the positive impact.		
Renewable or non-renewable resources			Groundwater only (see above).	The option does not significantly affect renewable or non-renewable resources, unless the requirements of the standard are lower / higher than those of the waters that naturally recharge aquifers at present times.	No significant impacts are expected.
The environmental consequences on firms and consumers		As the option is mainly expected to relaunch discussions in the country, no relevant impact is expected on sustainable production and consumption. In the longer term, if the practice becomes legal in France, it would contribute to improved sustainability of water and sanitation services provision.	The adoption of aquifer recharge with treated effluents would contribute to increasing the sustainability of the water use system in the country.	The option can lead to more sustainable groundwater use.	The positive impact in aquifer water quality would have positive consequences for all
Economic impacts	**Cyprus**	**France**	**Italy**	**Romania**	**Spain**
Operating costs and conduct of business/Small and Medium Enterprises	In the case of Cyprus, the standards considered for the IA stipulates strict limits for potable aquifers, following the DWD. Since the Cypriot standards already require secondary, advanced treatment (membranes) and disinfection the additional costs for treatment are not likely to be significantly higher. For non-potable aquifers, the standards considered for the IA are less stringent than the current Cypriot standards. Cypriot standards for non-potable water require secondary treatment and disinfection or	As the option is mainly expected to relaunch discussions in the country (rather than stimulate aquifer recharge), no relevant impact is anticipated on business and SMEs (e.g. water recycling plants). In the event that the French legislation is changed to allow aquifer recharge with treated wastewater (in the long term), this would open up additional opportunities for water treatment companies, as well as promoting the creation of new ventures and companies. At the same time, existing water treatment/recycling companies (e.g. those currently practicing	At present, aquifer recharge with treated effluents does not exist in the country. Additional transaction and compliance costs can be expected in those situations where a practice already exists, and a new regulation imposes for example stricter standards, or more complex permitting/control procedures. This would not be the case of aquifer recharge with treated wastewater in Italy. The introduction of this practice would involve significant investments for those entities wanting to engage in this practice, but this	Application of legally binding standards could increase the costs to water suppliers, since wastewater would need to undergo additional treatment to ensure the required quality. This would involve further investments, costs of sampling and testing etc.	Existing reclamation plants would need to upgrade their monitoring procedures to control for active substances in pesticides; this would imply additional costs. However, it is not possible to estimate a magnitude of these costs given the large range of costs showed for different technologies currently in use. Nevertheless, these costs might be higher as compared to the non-binding option. Whether new monitoring requirements (especially frequency) will be stricter or

Category of impacts					
Environmental impacts	**Cyprus**	**France**	**Italy**	**Romania**	**Spain**
	secondary, advanced treatment and disinfection. Implementation of the standards considered for the IA for non-potable water sources in Cyprus would result in lower cost of treatment but relatively higher cost of monitoring. The applicability would be limited to new plants, those already built may be difficult to retro-fit. On a balance, the total costs are anticipated to be similar to the baseline, i.e. to implementation of existing Cypriot standards. In the context of SMEs, positive impact is anticipated as agricultural businesses will benefit from an increased and/or better secured access to water.	water recycling for irrigation) would be likely to need to invest in additional treatment technologies, as quality requirements for treated wastewater for aquifer recharge are expected to be more stringent. On the other hand, if the discussion is relaunched private companies might start investing in research and development.	would be voluntary –and it would bring significant benefits for different stakeholders, for example in terms of increased water availability. In addition, at present it is not possible to forecast who would bear the investment costs. It might be that public authorities (e.g. regional authorities, in charge of water management; EU funding) would invest in this practice as it can be beneficial for society at large. However, in terms of operating costs for businesses, no relevant impact is expected.		easier to be attained by water operators is still to be defined.
Administrative burdens on businesses		In the event that the French legislation were to be aligned with the proposed requirements (in the long term) implying changes to allow aquifer recharge with treated wastewater, companies wanting to adopt this practice would be faced with additional obligations associated with permitting and monitoring.	In the event that the Italian legislation is changed to allow aquifer recharge with treated wastewater, companies wanting to adopt this practice would of course have legal obligations to fulfil (e.g. application for permits).	The administrative burdens would increase, since the national authority in charge of water resource management (National Administration Romanian Waters) would require monitoring data on treated wastewater. This would act as a burden on suppliers of treated wastewater.	No significant impact is expected due to the incorporation of an additional control parameter (active substances in pesticides) as compared to the current situation.
Public authorities	Changing the existing national frameworks to fit the proposed requirements may entail adoption of different conceptually different approach to regulating treated wastewater reuse. In the case of Cyprus such exercise is likely to result in additional administrative burden. However, in the case of minimum standards, Cyprus would be able to retain more stringent national standards.	As the option is mainly expected to relaunch discussions in the country, no relevant impact is expected on public authorities. However, public authorities (e.g. Water Agencies, Ministry of Environment, ONEMA, public research institutes) might be willing to invest in research and studies, as well as in experimental testing. This would imply some costs, but it would also contribute to the creation of a valuable knowledge base on aquifer recharge with treated wastewater.	Ensuring compliance with the EU standards would imply additional costs to the national administration, and in particular: (i) costs of developing the new law (background studies, legislative process including impact assessment); (ii) costs of adjusting the administrative system to implement the law (receiving and processing application, control of quality requirements, etc.).	If Romanian authorities were to decide to adopt treated wastewater reuse practice for aquifer recharge, public authorities would first have the responsibility to adapt and adopt the binding standards to the Romanian context. Adoption of standards could not be done without lifting the prohibition to discharge wastewater into groundwater. The expected low support from the Ministry of Environment, Waters and Forests in the adoption of these standards is also likely to act as a barrier. Implementation might also create technical problems, since	No significant impact is expected on budgets of public authorities. There would be additional costs of explaining operators the new scenario.

Category of impacts					
Environmental impacts	**Cyprus**	**France**	**Italy**	**Romania**	**Spain**
		In the event that water reuse for aquifer recharge is eventually adopted under French legislation (in the long term), this would imply additional costs for the national administration, and in particular: (i) costs of developing the new law (background studies, legislative process including impact assessment); (ii) costs of adjusting the administrative system to implement the law (receiving and processing application, control of quality requirements, etc.).		knowledge and experience on treated water reuse is missing. Monitoring and evaluation would also create burdens and costs for public authorities. It is possible that new departments would be created and / or new staff would be hired at the level of some authorities (e.g. National Administration Romanian Waters, public water operators, etc.).	
Innovation and research	Adoption of a clear and consistent EU framework would positively impact competitiveness and innovation removing some of the present barriers to investments in wastewater reuse technologies. Economies of scale and standardization opportunities, in turn, would support innovation and development of solutions at lower costs.	Relaunching the discussion on aquifer recharge with recycled water would definitely promote research and experimental testing of this practice, both by public authorities and universities and private actors.	This option is expected to significantly promote research and innovation in aquifer recharge with treated effluents.	The binding standards would come to the assistance of the research community, although there is no evidence that this subject had been so far approached by Romanian research institutes.	No significant impact is expected due to the incorporation of an additional control parameter (active substances in pesticides) as compared to the current situation.
Consumers and households	For potable aquifers, the additional costs for treatment are not likely to be significantly higher; for non-potable aquifers implementation of the standards considered in the IA in Cyprus would result in lower cost of treatment but relatively higher cost of monitoring. On a balance, the total costs are anticipated to be similar to the baseline, i.e. to implementation of existing Cypriot standards.	As the option is mainly expected to relaunch discussions in the country, no relevant impact is expected on consumers and households. If the practice is allowed by the French legislation in the future, the costs of recharging aquifers might be reflected in water users' bills. However, this might occur in the long term, and at present is not possible to say anything more specific about the expected impacts on water bills.	If and when this practice is adopted, the costs of recharging aquifers might be reflected in water users' bills. However, at present is not possible to say anything more specific about the expected impacts on water bills, especially because it is not possible to forecast who would bear the costs of aquifer recharge with treated effluents, and how these costs would be recovered (different entities can be involved, and different	If and when this practice is adopted, the costs of recharging aquifers might be reflected in water users' bills affecting water consumers. However, having regard to the fact that currently aquifers are not recharged with treated wastewater, concerns about the practice might prevent Romania to adopt the practice (at least in the short to medium term) resulting in significant impacts on consumers.	Additional costs for water reclamation plants would imply increased costs for water users. Alternatively, as it often happens, additional costs might recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users).

Category of impacts					
Environmental impacts	**Cyprus**	**France**	**Italy**	**Romania**	**Spain**
			financing and cost-recovery schemes could be applied).		However, estimating a possible magnitude of this impact, and on whom, is impossible with available data and information. On the other hand, enhancing water security will have positive economic effects on end users.
Social impacts	**Cyprus**	**France**	**Italy**	**Romania**	**Spain**
Employment and labour markets	The establishment of an EU wide legally binding framework together with improved communication on actual risks and benefits of water reuse is expected to have a positive impact on confidence of the general public in the quality of the reused water and, therefore, on acceptance of water reuse as a water management tool.	The promotion of research and innovation on treatment technologies for aquifer recharge might increase the demand for qualified personnel in the field of wastewater treatment and recycling (private and public). Background studies on the introduction of this technology in France might involve contributions from research organisations (with associated positive impacts on employment). If the practice becomes legal in the country, additional jobs would be created (assuming legalisation promotes uptake). However as the standards considered in the IA are relatively strict, the practice is expected to have limited adoption resulting in a limited impact on the labour market. However, it is very difficult to infer something more than qualitative about the possible impact on the labour market. It can reasonably be expected that water recycling for aquifer recharge would be a niche sector, so the macro-economic	This option might increase the demand for qualified personnel in research and pilot testing of aquifer recharge techniques with treated effluents. Once the practice is regulated and established in the country, additional jobs would be created in the sector. However, it is very difficult to infer something more than qualitative about the possible impact on the labour market. It can reasonably be expected that water recycling for aquifer recharge would be a niche sector, so the macro-economic impact would be very limited (both in case of research and development on the topic and in case of future adoption of this practice).	If and when this practice is adopted in Romania, promotion of water reuse for aquifer recharge in Romania might increase demand for technical and scientific personnel and create new jobs in water treatment and innovation and research.	No significant impact is expected due to the voluntary incorporation of an additional control parameter (active substances in pesticides) as compared to the current situation.

Category of impacts					
Environmental impacts	**Cyprus**	**France**	**Italy**	**Romania**	**Spain**
		impact would be very limited (both in case of research and development on the topic and in case of future adoption of this practice).			
Governance, participation, good administration, access to justice, media and ethics		The development of EU standards, as well as the consequent relaunch of discussions in the country, might bring the practice to the attention of the public. In addition, the existence of EU standards could positively steer public perception and acceptance of this practice.	The adoption of common EU standards would protect water users and would result in better awareness about the quality of water being used. In addition, the existence of EU standards could positively steer public perception and acceptance of this practice.	Promotion of minimum water quality standards for aquifer recharge across the EU would ensure consistent levels of consumer protection and would result in increased awareness about the quality of water being use	Enhanced water security would have a positive impact.
Public health and safety		As the option is mainly expected to relaunch discussions in the country, no relevant impact is expected on public health and safety. Nevertheless, by promoting public debate and research on the topic, this option would indirectly increase knowledge on aquifer recharge with recycled water: research and experimental testing might improve existing technologies, also in terms of safety and thus public health. In the event that the practice becomes legal in the country (in the long term), it can be expected that quality standards would be very stringent, so no negative impacts on public health and safety are anticipated.	Research and pilot testing might improve existing technologies, also in terms of safety and thus public health. Once the EU regulation is adopted in the country, quality standards are expected to protect public health.	If and when the practice is adopted in Romania, adoption of EU wide minimum water quality requirements would ensure a consistent level of protection of the human health and safety of individuals/populations The option would also decrease the likelihood of health risks due to substances harmful to the natural environment. Romania has very little experience with wastewater reuse in aquifer recharge. Legally binding framework ensuring consistent and appropriate control of delivered wastewater would provide an extra reassurance in the practice to all partners involved, mitigating the risk of accidents or mishandling of the treated wastewater.	The current Spanish regulation is already protecting the population against the possible risks.
Governance, participation, good administration, access to justice, media and ethics		The development of EU standards, as well as the consequent relaunch of discussions in the country, might bring the practice to the attention of the public. In addition, the existence of EU	The adoption of common EU standards would protect water users and would result in better awareness about the quality of water being used. In addition, the existence of EU standards could positively	Promotion of minimum water quality standards for aquifer recharge across the EU would ensure consistent levels of consumer protection and would result in	

Category of impacts					
Environmental impacts	**Cyprus**	**France**	**Italy**	**Romania**	**Spain**
		standards could positively steer public perception and acceptance of this practice.	steer public perception and acceptance of this practice.	increased awareness about the quality of water being use	
Public health and safety		As the option is mainly expected to relaunch discussions in the country, no relevant impact is expected on public health and safety. Nevertheless, by promoting public debate and research on the topic, this option would indirectly increase knowledge on aquifer recharge with recycled water: research and experimental testing might improve existing technologies, also in terms of safety and thus public health. In the event that the practice becomes legal in the country (in the long term), it can be expected that quality standards would be very stringent, so no negative impacts on public health and safety are anticipated.	Research and pilot testing might improve existing technologies, also in terms of safety and thus public health. Once the EU regulation is adopted in the country, quality standards are expected to protect public health.	If and when the practice is adopted in Romania, adoption of EU wide minimum water quality requirements would ensure a consistent level of protection of the human health and safety of individuals/populations The option would also decrease the likelihood of health risks due to substances harmful to the natural environment. Romania has very little experience with wastewater reuse in aquifer recharge. Legally binding framework ensuring consistent and appropriate control of delivered wastewater would provide an extra reassurance in the practice to all partners involved, mitigating the risk of accidents or mishandling of the treated wastewater.	

D3 Detailed case studies

1. Cyprus

1.1 Cyprus: A wastewater reuse pioneer in Europe

Overview

Cyprus has an intense Mediterranean climate with typical seasonal variation of temperature, rainfall and weather. Autumn and spring are characterised by fast changing weather while the dry summer last from mid-May to mid-September and the rainy winter last from November to mid-March. Most of the rainfall is registered during the winter with about 60% of the average annual total precipitation falling from December to February. This varies annually but also geographically with rainfall of 280 mm in the central plains and up to 1000 mm on the Troodos mountain peak (altitude 1950 m) with a mean annual precipitation of 497 mm. The total annual water supply is 3029.80 million cubic metres (Mm^3), 89.4% of which is lost on average in evaporation leaving 320.90 Mm^3 as useable water. This percentage can reach up to 95% in the driest years.

Table 1.1 Water resources: long-term annual average (LTAA)

Water process	**LTAA**	
	m3/habitant	*Mm3*
Precipitation	*3 499.11*	*3 029.80*
Actual evapotranspiration	*3 128.62*	*2 709.00*
Renewable freshwater resources	*370.61*	*320.90*
Internal Flow	*370.61*	*320.90*
Total actual outflow	*92.62*	*80.20*

Source: Eurostat (ten00001) Publication date: 18 February 2016

Cyprus depends as far as natural water resources are concerned, solely on rainfall. Winter rainfall is the main source for the replenishment of water resources since summer rains do not contribute significantly to the recharge of aquifers[1,2,3].This is because the small amounts that do fall in summer are rapidly absorbed by the dry soil or soon evaporated by the high temperatures. As a result most crops require significant irrigation. Historically, in Cyprus, droughts occur every two-to-three years. In the last fifty years, and due to a decline in rainfalls, drought incidences have increased both in magnitude and frequency.

In 2008, Cyprus faced one of the most acute and prolonged droughts (a fourth consecutive drought year) with an extremely dry winter season where the inflow to the reservoirs was approximately only 19 Mm^3. Water reserves of underground aquifers were drastically reduced and the water storage in the dams had reached dangerously low levels.

In response to the acute recent droughts in Cyprus, a series of measures to manage users' demand were adopted and encouraged by the Government. Such management measures include water rationing, increase of public awareness on water conservation methods and water pricing for improvement of water use

[1] Water Scarcity in Cyprus: A Review and Call for Integrated Policy, Anastasia Sofroniou and Steven Bishop

[2] Hochstrat, R.; Kazner, C. *Flexibility of Coping with Water Stress and Integration of Different Measures*; Case Study Report Cyprus of European Commission Funded Project Technology Enabled Universal Access to Safe Water (TECHNEAU): Brussels, Belgium, 2009

[3] Pashiardis, S. Trends of precipitation in Cyprus rainfall analysis for agricultural planning. In Proceedings of the 1st Technical Workshop of the Mediterranean Component of CLIMAGRI Project on Climate Change and Agriculture, Rome, Italy, 25–27 September 2002

efficiency and water saving. The Government of the Republic of Cyprus has also taken measures to tackle the water poverty by creating desalination plants, recycling water methods, and utilising dams in order to increase water supply capacity.

The Water Development Department (WDD) is responsible for implementing the Government's water policy, to provide effective protection, rational development and sustainable management of water resources in Cyprus. The Government's water policy focuses on addressing water scarcity and droughts and uncontrolled exploitation. Within the framework of the Government's water policy, other nonconventional water resources, such as recycled water (the use of which releases equal quantities of good quality water), desalination of seawater and brackish groundwater as well as rainwater utilisation are promoted. In addition, the cultivation of a water saving culture is promoted across all citizens.

In Cyprus, desalinated water is an additional resource for public water supply and to support holiday resorts in arid areas. Desalination on a large-scale basis was introduced in 1997 with the operation of the 20,000 m^3 per day, reverse osmosis plant at Dhekelia. Due to the drought prevailing at the time, the plant was expanded to 40,000 m3 per day[4]. The plant operates on a Build-Own-Operate-Transfer (BOOT) basis and the desalinated water is presently sold to the Government. The WDD proceeded with the construction of another desalination plant in Larnaka and a mobile desalination unit in the Limassol district, to minimise the dependence on weather conditions and secure sufficient potable water. Future plans include the construction of another desalination plant near Limassol and of mobile units installed on ships that cruise the Cypriot coastline.

In 2009, the domestic water demand amounted to 70.3 Mm^3, of which desalination contributed to 49.4 Mm^3 per year[5]. Therefore, the desalination plants contributed to 70% of the total domestic water. In 2013, a different picture could be observed, where only 14% of the total domestic water came from desalination.[6] This drop in domestic demand for water from desalination plants was compensated by an increase in the domestic demand of water coming from dams. This increase was a product of the decision to operate desalination plants at their lowest possible production capacity and most of the plants were set in standby mode. These instructions were according to contractual provisions, which allow the Water Development Department to manage the water production taking into account the water reserves[7].

The potential for recycled water depends on the availability and accessibility of wastewater, hence, the wastewater infrastructure becomes a critical factor as does the users acceptance. The reuse of water (known in Cyprus as "recycled water") provides an additional drought proof water supply. The use of recycled water has mostly been for irrigation and to mitigate the overdependence of agriculture on groundwater[8,9]. Most of the recycled water is used directly for irrigation with orchards being the most irrigated crops (in particular citrus and olive trees) but also cow grass.

Furthermore, environmental benefits are attained by using recycled water to recharge depleted aquifers and reduce sea-water intrusion. This is the method used in Paphos, where the Ezousa aquifer is recharged artificially with 2–3 Mm^3 recycled water per year, which is then re-abstracted for irrigation[10],[11]. Most recently, the WDD started using the rapidly depleting Akrotiri aquifer as a storage tank. The aquifer is being recharged with recycled water in order to reduce the effects of sea intrusion.

[4] Water Scarcity in Cyprus: A Review and Call for Integrated Policy, Anastasia Sofroniou and Steven Bishop
[5] Water Development Department Homepage. Available online: http://www.moa.gov.cy
[6] Water Development Department Homepage. Available online: http://www.moa.gov.cy
[7] Water Scarcity in Cyprus: A Review and Call for Integrated Policy, Anastasia Sofroniou and Steven Bishop
[8] Pashiardis, S. Trends of precipitation in Cyprus rainfall analysis for agricultural planning. In Proceedings of the 1st Technical Workshop of the Mediterranean Component of CLIMAGRI Project on Climate Change and Agriculture, Rome, Italy, 25–27 September 2002

[9] Eighth Report on the Implementation Status and the Programmes for Implementation (as required by Article 17) of Council Directive 91/271/EEC concerning urban waste water treatment

[10] Water Scarcity in Cyprus: A Review and Call forIntegrated Policy, Anastasia Sofroniou and Steven Bishop

[11] Eighth Report on the Implementation Status and the Programmes for Implementation (as required by Article 17) of Council Directive 91/271/EEC concerning urban waste water treatment

Overall water reuse for irrigation and recharge purposes is a growing activity in Cyprus.

'Grey water' is also used as a means of reducing the consumption of water in households, other living quarters such as hotels and a few types of industry such as laundries. Water, which is used for washing (e.g. wash-hand basins, baths, showers, washing machines and dishwashers), is collected in a separate system and filtered. It is then used for example for domestic irrigation. This form of water reuse is rapidly growing;

Water stress, scarcity and droughts in Cyprus

Cyprus is the most water stressed country of the European Union, with a water exploitation index (WEI) of approximately 66%. Table 1.2 present the evolution of the WEI in Cyprus since 2004 and Table 1.3 compares Cyprus' WEI with other Mediterranean countries.

Table 1.2 Evolution of the water exploitation index in Cyprus

WEI %	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Fresh surface water	63.10	54.90	36.00	33.30	21.50	16.70	38.90	50.90	51.80	52.10
Fresh groundwater	101.40	112.20	112.20	101.40	105.00	94.10	105.00	101.40	101.40	124.50
Surface and Groundwater	79.60	79.60	68.80	62.60	57.40	50.00	67.40	72.60	73.10	83.30

Source: Eurostat tsdnr310 | Publication date: 19 February 2016, CET (Water Exploitation Index - Percentage)

Table 1.3 Comparison of Cyprus' WEI with other Mediterranean countries

WEI %	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Greece							13.20	13.10	13.40	13.30
Turkey		21.60		20.00	19.30	17.90	16.90	18.70	19.10	19.20
Malta	58.10	51.20	48.80	52.40	40.60	45.90	47.20	41.70	41.50	40.40
Spain		33.60	32.60	32.00	32.50	31.80	32.0			
Cyprus	**79.60**	**79.60**	**68.80**	**62.60**	**57.40**	**50.00**	**67.40**	**72.60**	**73.10**	**83.30**

Source: Eurostat tsdnr310 | Publication date: 19 February 2016, CET (Water Exploitation Index - Percentage)

Figure 1.1 presents the evolution of water exploitation index in Cyprus per category of water (surface, groundwater and both)

Figure 1.1 Evolution of water exploitation index in Cyprus per category of water (surface, groundwater and both)

Source: Eurostat tsdnr310 | Publication date: 19 February 2016, CET (Water Exploitation Index - Percentage)

The high water exploitation index can be explained by: the exploitation of the island's water resources, the diminishing volume of both groundwater and surface water storage, leading to shorter retention times and by the deterioration of water quality due to pollution.

Sources of water have evolved:

- In 1991 36.3 Mm^3 was exploited (34% from dams and 66% from abstraction sources such as boreholes);
- In 1997, the year desalination of sea water was first introduced on a large scale, 44.8 Mm^3 of water was exploited (45% from dams, 43% from abstraction sources and 12% from recycled water sources via desalination plants);
- In 2005 water exploitation reached 73.3 Mm^3 (35% came from dams, 23% from abstraction and 42% from recycled water sources);
- In 2008, the year of the severe drought, more than half of the water sources (52%) came from desalination plants; and
- In 2013, the domestic supply of water sources was 77.5 Mm^3, of which 76% came from dams, 10% from abstraction sources and 14% from desalination plants.[12]

Figure 1.2 illustrates the evolution of water demand by source and by sector.

[12] Water Development Department Homepage. Available online: http://www.moa.gov.cy

Figure 1.2 Overview of water abstraction by source and by sector

Source: Eurostat (ten00002) | Publication date: 18 February 2016, CET (Water abstraction by source - million c.m)

Water reuse potential

Water reuse provides additional drought-proof water supply, favours a local sourcing of water and avoids the use of drinking water quality water for uses where such high quality is not needed. The potential for water reuse depends on the availability and accessibility of wastewater (i.e. the wastewater infrastructure) and the acceptability by potential end-users and consumers. Cyprus has adopted a 'Not a Drop of Water to the Sea' policy encouraging the maximum capture of run-off by dam construction and handling of wastewater.

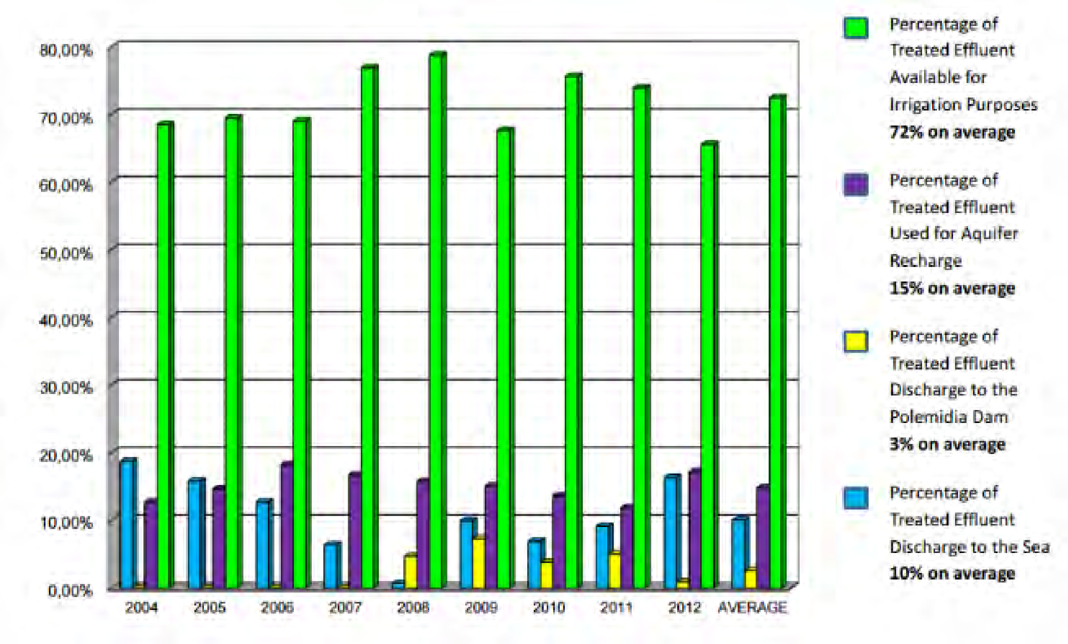
The use of recycled water for irrigation through, began in 1998, with a relatively small quantity of around 1.3 $x10^6$ m^3. In 2011, $12x10^6$ m^3 of recycled water was provided for irrigation and about 2.5 $x10^6$ m^3 for artificial recharge of aquifers. Furthermore, an exponential increase in the amounts available in the future is expected. The capacity of the new Waste Water Treatment Plans was expected to reach in 2015 up to $65x10^6m^3$ per year and $85x10^6$ m^3 for long term (2025)[13].

Figure 1.3 shows the evolution of the uses made of treated effluents. In general, about 90% of treated wastewater is reused, primarily for the irrigation of agricultural land, parks, gardens and public greens. A small proportion (15% on average) is used for groundwater aquifer recharge. Near the city of Paphos, the Ezousa aquifer is recharged artificially with 2-3Mm^3 reclaimed water per year, which is then re-abstracted for irrrigation. The aquifer would be able to store a total of 5 Mm^3 from the municipal wastewater treatment plant[14].

[13] Ministry of Agriculture, Natural Resources and Environment Water Development Department River Basin Management Plan, April 2011

[14] Christodoulou, G.I., Sander, G.C. and. Wheatley, A.D (2007). Characterization of the Ezousas aquifer of SW

Figure 1.3 Evolution of uses of treated effluent since 2004



Source: Ministry of Agriculture, Natural Resources and Environment Water Development Department River Basin Management Plan, April 2011

Currently, the contribution of recycled water to irrigation water supplied through the Government Water Works makes up about 10% of the demand which equals 13-15 Mm^3. After full implementation of the planned schemes, the reclaimed water flow was expected to increase gradually as summarised in Table 1.4.

The annual water recycling is expected to provide 52 Mm^3 by 2012-2014 which would represent 28.5% of the current agricultural water demand[15].

Table 1.4 Estimated volumes of treated wastewater

	2012	2015	2025
Municipal wastewater treatment plants	46 Mm^3/yr	51 Mm3/yr	69 Mm^3/yr
Rural wastewater treatment plants	13 Mm^3/yr	14 Mm3/yr	16 Mm^3/yr
Total	59 Mm^3/yr	65 Mm3/yr	85 Mm^3/yr
Annual water recycling	52 Mm^3/yr		

Source: Estimated volumes of treated wastewater from WDD

Current reuse in Cyprus

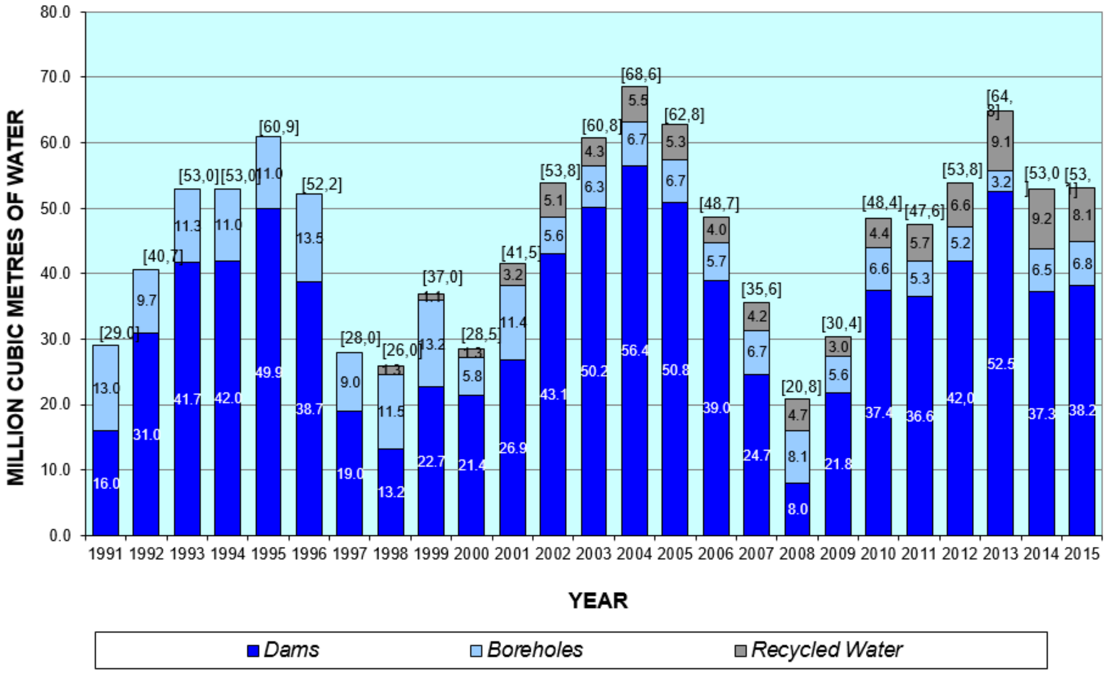
Cyprus is an island where tourism is an important economic activity. Water scarcity and deterioration of bathing water are preventing tourism development. The reuse of reclaimed water is seen as a solution for both of these problems.

The government water policy focuses on the maximum potential exploitation of non-conventional water resources, such as recycled water, the use of which produces equal quantities of good quality water. Tertiary treated recycled water is used for irrigation of existing cropping land and for recharging aquifers. Full exploitation of recycled water is a long-term costly process, the success of which will decrease or even

[15] Water Reuse in Cyprus, Iacovos Papaiacovou and Constantia Achileos, Ioanna Ioannidou, Alexia Panayi, Christian Kazner, and Rita Hochstrat -Cyprus-Irrigation- 2012 Guidelines for Water Reuse

eliminate the necessity to build more desalination plants[16]. Figure 1.6 shows that treated effluent is a growing resource in Cyprus[17].

Figure 1.4 Government Water Works – Irrigation Supply Sources (1991-2015)



Treated Effluent Reuse is a reliable source of water which enhances the water balance for the following:

- Domestic Sector – Cities:
  - Freshwater can be reserved to satisfy the increasing demand for potable water;
  - Need for fewer desalination plants;
  - Lower carbon footprint;
  - Less dependence on oil prices; and
  - Keep water prices at reasonable levels.
- Agricultural Sector Farmers:
  - Constant source of water;
  - Savings in fertilizers;
  - Increase crop yield; and
  - Maintain traditional agriculture.
- Environment:
  - Reduce discharge to WBs;
  - Reduce abstraction;
  - Groundwater replenishment; and

[16] http://www.moa.gov.cy/moa/wdd/wdd.nsf/planning_en/planning_en?OpenDocument
[17] http://www.moa.gov.cy/moa/wdd/wdd.nsf/All/C863C3E09F8C2C7EC2256FAB00330969?OpenDocument

- Control saltwater intrusion.

However, some issues have arisen with the reuse of water which are as follows:[18]:

- Farmers and Public acceptance;
- Health risk from associated pathogens;
- Health risk from other contaminants (e.g. metals, chemicals, pharmaceuticals);
- Decrease in soil quality from accumulation of metals and acidification; and
- Infiltration of groundwater.

Cyprus minimises the risks presented through the following actions: strict Regulation requiring advanced Treatment, adoption of a mandatory Code of Practice, quality control and research (Agricultural Research Institute of Cyprus and the University of Cyprus).

Several studies have been conducted in Cyprus in order to assess the potential impacts of irrigation with treated municipal wastewater on crops[19]. Research results concerning the long-term wastewater irrigation of forage and citrus revealed no impacts on both soil physicochemical properties and heavy metal content, as well as on agricultural produce heavy metal content. Research results concerning wastewater irrigation of tomato crops showed no accumulation of heavy metals in tomatoes, whereas total coliforms and fecal coliforms were not quantified in both tomato flesh and peel, and E.coli, Salmonella spp and Listeria spp were not detected in tomato homogenates (Tomato plants were drip irrigated in accordance with the Code of Good Agricultural Practice). Research on pharmaceutical compounds detected traces of these compounds in treated effluent but further research is going on to assess whether they are being taken up by plants under field conditions. [20]

In Cyprus, the government policy is to bear the cost of tertiary treatment and the cost of infrastructure (pipelines, pumping and storage ponds) to take reclaimed water to agricultural areas. The farmers bear the cost of transferring water from the distribution pipeline up to their farm outlet in the case of new irrigation networks.

There was a lot of reaction and skepticism from farmers at the early days of implementing water reuse projects in Cyprus, due to ignorance, misconceptions and psychological fear.

Acceptance issues were addressed through information / consultation campaigns, education of the farmers in small groups, the adoption of regulation and a code of conduct, financial incentives making recycled water much cheaper than freshwater and demonstrating benefits in practice. [21] A Pilot irrigation area of 30 ha close to Limassol WWTP was initiated to demonstrate that recycled water enhances agricultural productivity and is safe to use by the farmers – Sorghum, alfalfa and corn were used as verified crops irrigated with effluent water for a period of 2 years. The Agricultural Research Institute was responsible for the collection and analysis of all data and verification of the results which found an increased crop yield increased by 30% on average.

In 2014, agricultural irrigation with recycled water satisfied the needs of 5.000 ha in total, through existing and new irrigation networks.[22]

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[18] Reuse of Treated Efflent in Cyprus, Presentation, Brussels March 2015, Panayiota Hadjigeorgiou Senior Executive Engineer, Water Development Department Ministry of Agriculture

[19] Research works carried out by the University of Cyprus, presented during the CIS PoM working group meeting of 25/03/1419 -Draft Guidance Waterreuse-https://circabc.europa.eu/.

[20] Reuse of Treated Effluent in Cyprus, Presentation, Brussels March 2015, Panayiota Hadjigeorgiou Senior Executive Engineer, Water Development Department Ministry of Agriculture

[21] Reuse of Treated Effluent in Cyprus, Presentation, Brussels March 2015, Panayiota Hadjigeorgiou Senior Executive Engineer, Water Development Department Ministry of Agriculture

[22] Reuse of Treated Effluent in Cyprus, Presentation, Brussels March 2015, Panayiota Hadjigeorgiou Senior Executive Engineer, Water Development Department Ministry of Agriculture

1.2 Wastewater collection infrastructures and treatment

Infrastructures for wastewater collection

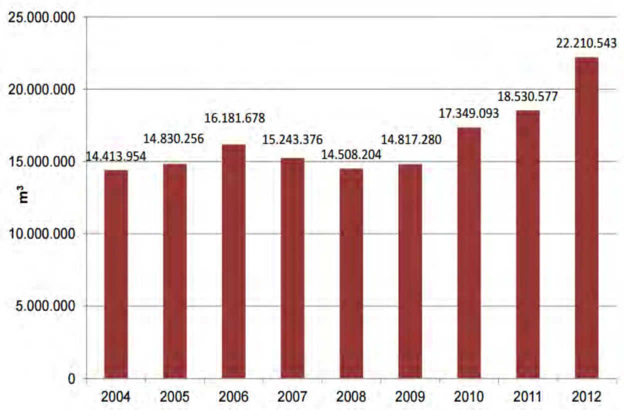
There are 34 major UWWTPs (Urban Waste Water Treatment Plants) currently in operation in Cyprus as presented in Table 1.5. Apart from these treatment plants, which serve the big cities some municipalities and rural communities, there are some smaller UWWTP (around 175) located in hotels, military bases and hospitals. Centralized sewerage networks and UWWTPs cover part of the broader areas of Nicosia, Limassol, Larnaca, Pafos, Agia Napa and Paralimni, serving 45% of the total urban population. The rural population represents 30% of the total island population. Centralised sewerage networks, now serve 12% of the rural population. In the remaining rural areas the traditional methods for sewage disposal are absorption pits and septic tanks.

Table 1.5 Overview of UWWTP in Cyprus

Existing Urban Wastewater Treatment Plants	Number of WWTPs	Total Capacity (m3/sec)
Existing Urban WWTPs (>2000pe)	8	165.700
Existing Rural WWTPs (>2000pe)	7	2601
Existing Rural WWTPs (<2000pe)	4	506
Existing WWTPs for Refugee Housing	3	760
Existing WWTPs for Hospitals	3	1280
Existing WWTPs for Military Camps	9	684
Total	34	

Figure 1.5 presents the evolution of the volume of treated effluents from the WWTP between 2004 and 2012 and shows a constant increase since 2009.

Figure 1.5 Volumes of treated effluent in Cyprus (2004-2012)



Treatments available in WWTPs

Table 1.6 presents the wastewater treatment methods applied in urban wastewater treatment plants.

Table 1.6 Overview of the treatments used in Cyprus WWTPs

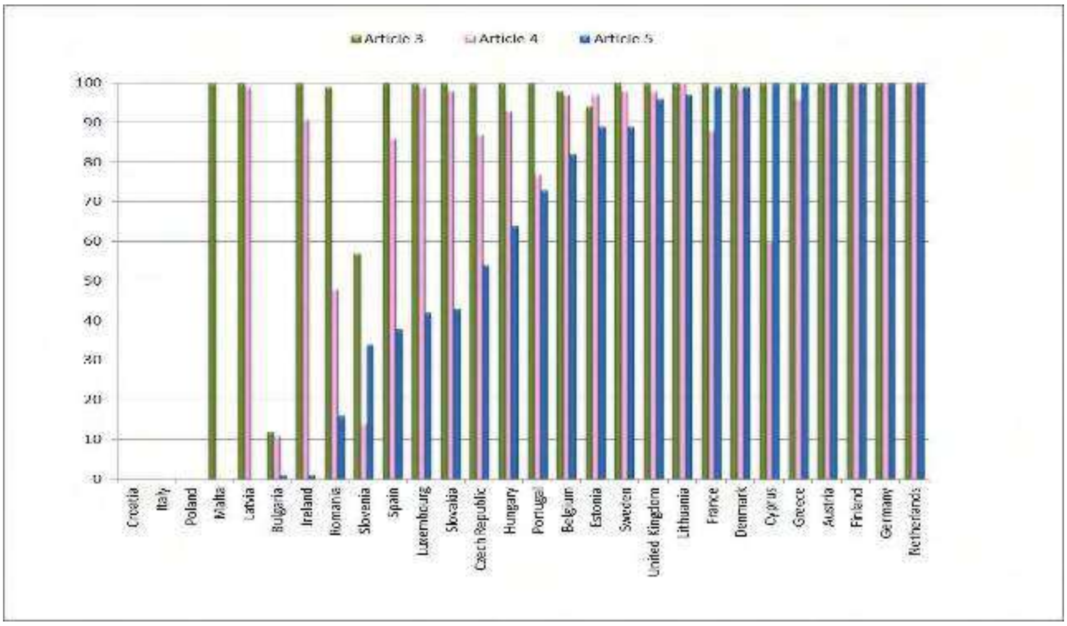
Plant	Owner of the Plant	Capacity (m³/day)	TYPE OF SECONDARY TREATMENT	TYPE OF TERTIARY TREATMENT
Anthoupoli	Nicosia Sewerage Board	13,000	Activated sludge membrane bioreactor , nitrification - denitrification, phosphorus removal	Membrane bioreactor
Vathia Gonia	Nicosia Sewerage Board	21,000	Activated sludge membrane bioreactor, nitrification - denitrification, phosphorus removal	Membrane bioreactor
Vathia Gonia	Water Development Department	2,200	Activated sludge extended aeration -oxidation ditches	Sand filters
Paralimni –Ayia Napa	Sewerage Board of Paralimni-Ayia Napa	21,000	Activated sludge, nitrification - denitrification, phosphorus removal	Sand filters
Limassol (Moni)	Sewerage Board of Limassol Amathus	40,000	n.a	n.a
Larnaca	Sewerage Board of Larnaca	18,000	n.a	n.a
Mia Milia	n.a	30,000	n.a	n.a

The Nicosia Bi-communal Wastewater Treatment Plant (WWTP) is located in the Mia Milia / Haspolat area of Nicosia, Cyprus. The construction of the plan was estimated to cost €29m and began in March 2010 and trial operations were conducted in June 2013. The WWTP was commissioned in April 2014.

Compliance with EU legislation

Figure 1.6 presents the results of compliance of Member States for Articles 3 (collection), 4 (secondary treatment), and 5 (more stringent treatment) of the UWWTD.

Figure 1.6 Overview of compliance with UWWTD of Member States in 2012



Source: Eighth Report on the Implementation Status and the Programmes for Implementation of CD91/271/EEC, 2016[23].

[23] Eighth Report on the Implementation Status and the Programmes for Implementation, https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/1-2016-105-EN-F1-1.PDF

The WDD is responsible for the implementation of the national groundwater monitoring programs in accordance with the Water Framework Directive.[24] An overview of the compliance of Cyprus' agglomerations in 2011 is presented in Table 1.7.

Table 1.7 Legal compliance check for agglomerations ≥ 2,000 p.e. in Cyprus as reported for reference date 31 December 2011 on NUTS2 level

CYPRUS: CY00 (Kypros/Kipros) (NUTS 2 code)					**Compliance rate**		
total number of agglomerations	total generated load	load collected in collecting systems		number of agglomerations in breach	Article 3	Article 4	Article 5
		p.e	%		% of generated load	% of collected load	% of collected load
57	995,000	701,277	70	1	100	60	100

Source: Eighth Report on the Implementation Status and the Programmes for Implementation of CD91/271/EEC

Wastewater treatment costs

In Cyprus the wastewater generated by the main cities, about 25 million m³/yr, is planned to be collected and used for irrigation after tertiary treatment. Because of the high transportation cost, it is anticipated that most of the recycled water, about 55 to 60%, will be used for amenity purposes used as hotel gardens, parks, golf courses, etc. A net of about 10 million m³ is conservatively estimated to be available for agricultural irrigation.[25]

An interesting case in Cyprus is the Larnaca wastewater reuse system. Since the plant has been in operation (year 2000), the effluent is being used for irrigation of 150 hectares of agricultural land at Dromolaxia Village where corn and alfalfa are cultivated. The treated water is also used by the hotels, International Airport and Larnaca Municipality for the irrigation of gardens, parks and fields during the summer season. For that purpose, the effluent is being discharged through pumping stations. The total cost of the project is €50 million, out of this, €9.3 million is the cost of the tertiary treatment plant with the reuse network and pumping station. The cost for the production of tertiary treated water is around 0.5 €/m³ (Hidalgo *et al*, 2004). [26]

Another remarkable case in Cyprus is the reuse system in Cavo Greco area. Since the plant has been in operation, the effluent is being used for irrigation of agricultural land in Paralimni where potatoes are mostly cultivated. The treated water is also used by the hotels and the Municipalities for the irrigation of gardens and parks during the summer season. The total cost of the plant has been €14.4 million, out of this €5.9 million, is the cost of the tertiary treatment plant with the reuse network and pumping station. The cost for the production of tertiary treated water is around 0.50 €/m³ (35 cents for secondary treatment and 15 cents for tertiary treatment). The Sewerage Board of Paralimni and Ayia Napa sells this water at the price of 0.25 €/m³ for the hotels and 0.10 €/m³ for agriculture (Hidalgo *et al*, 2004). [27]

The price of water is the most visible signal for its valuation and an appropriate means to manage demand. At least the price should reflect the scarcity of the good and prevent from wasteful use. The established increasing block-tariff reflects this approach. Recent price increase in Paphos charges rates as high as 8 €/m³ for excessive use. A summary of water prices is listed in Table 1.8.[28]

[24] WWD, Annual Report, http://www.moa.gov.cy/moa/wdd/wdd.nsf/All/

[25] The cost of wastewater reclamation and reuse in agricultural production in the Mediterranean countries,D. Hidalgo and R. Irusta,2005

[26] The cost of wastewater reclamation and reuse in agricultural production in the Mediterranean countries,D. Hidalgo and R. Irusta,2005

[27] The cost of wastewater reclamation and reuse in agricultural production in the Mediterranean countries,D. Hidalgo and R. Irusta,2005

[28] Case Study Report Cyprus, Techneau 2010

Table 1.8 Water prices in Cyprus

Drinking Water		Prices EUR/m3
Purchase of bulk water from WDD29		0.77
Limassol (Water Board of Limassol website) 30	from 1m³ - 40 m³	0.90
	from 41m³ - 80m³	1.40
	from 81m³ - 120m³	2.35
	from 121m³	5.00
Paphos	from 21 - 30 m³	2.0
	from 30 m³	8.0
Irrigation water		Prices EUR/m3
From Government Water Works	Within quota	0.19
	Sports grounds - hotel greens & gardens	0.34
	Exceeding quota	0.57
Reclaimed water	agricultural production - irrigation division	0.05
	agricultural production - private person	0.07
	Sports grounds - hotel greens & gardens	0.15
	golf courses	0.21
	pumping of reclaimed water from GWR	0.08

Table 1.9 presents the evolution of water productivity in Cyprus. The unit in chain linked volumes allows observing the water productivity trends over time in a single geographic area.

Table 1.9 Evolution of water productivity in Cyprus (EUR per m3)

Water productivity	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Euro per cubic metre	69.00	73.30	86.90	95.20	102.30	119.90	85.90	75.90	72.10	61.00

Note: reference year 2010, at 2010 exchange rates

1.3 Existing regulation in Cyprus

In Cyprus the use of the discharge of effluent from urban wastewater treatment plants is regulated by:

- The Environmental Impact Assessment Law (No. 140(I)/2005);
- The Water Pollution Control Laws (106(I)/2002 to 2009);
- The Water Pollution Control (Recycled Water Quality) Regulations of 2015 (No. 379/2015);
- The Water Pollution Control (Discharge of Urban Waste water) Regulations of 2003 (No. 772/2003);
- The Water Pollution Control (Sensitive Areas for Disposal of Urban Waste Water) Min. Decree of 2004 (No. 111/2004);
- The Code of Good Agricultural Practice Decree (No. 263/2007);
- The Ministerial Decree of small-scale wastewater treatment plants < 2000 p.e. (No. 269/2005);

[29] http://www.moa.gov.cy/moa/wdd/Wdd.nsf/index_en/index_en?OpenDocument
[30] http://www.wbl.com.cy/english/index.php?article_id=9&subject=standalone&parent_id7

- Water reuse provisions are fully integrated into the legislation on urban wastewater treatment and discharge (State Law N.106(I)/2002, as amended); and
- The Code for Good Agricultural Practice (K.D.P. 407/2002) is intended to ensure further protection of public health and the environment and indicates for each potential use which specific irrigation methods are prescribed. Water quality requirements of recycled water vary depending on the level of potential public exposure.

As part of the transposition of the UWWT Directive and the IPPC/IE Directives, Cyprus issued the State Law N.106(I)/2002 concerning 'The Control of the Waters Pollution' and the associated regulations K.D.P. 407/2002, 772/2003 254/2003, KDP269/2005. According to this law, the operation of any establishment, which might cause the pollution of the soil and/or the waters, is forbidden, unless it is covered by a Wastewater Discharge Permit. These permits are issued by the Minister of Agriculture Natural Resources and Environment for the Sewerage Boards and the Water Development Department. Permits specify the quality objectives and the disposal conditions of the treated wastewater as well as legally-binding numerical limit values for a range of parameters. They apply at the outlet of the WWTP.

Quality criteria for the treated wastewater take the specific conditions of Cyprus into account; in particular, conventional secondary treatment has been preferred to stabilisation ponds in some areas because of the high cost of land (coastal areas) and for protection of environmental and aesthetic amenities for tourism.

A summary of water quality parameters of concern are shown in Table 1.10, with respect to their importance in water reuse systems and approximate ranges of each parameter in raw sewage and reclaimed water.

Table 1.10 Summary of Water Quality Parameters of concern for water reuse

Parameter	Range in secondary effluents	Treatment goal in reclaimed water	Significance for water reuse
Suspended solids	5 – 50 mg/L	<5 – 30 mg SS/L	Measures of particles. Can be related to microbial contamination. Can interfere with disinfection. Clogging of irrigation systems. Deposition.
Turbidity	1– 30 NTU	<0.1 – 30 NTU	
BOD5 **COD** **TOC**	10 - 30 mg/L 50 - 150 mg/L 5 - 20 mg/L	<10 – 45 mg BOD/L <20 - 90 mg COD/L <1 - 10 mg C/L	Organic substrate for microbial growth. Can favour bacterial re-growth in distribution systems and microbial fouling.
Total coliforms	<10 -107 cfu/100ml	<1 - 200 cfu/100mL	Measure of risk of infection due to potential presence of pathogens. Can favour biofouling in cooling systems.
Faecal coliforms	<1-106 cfu/100ml	<1 - 103 cfu/100mL	
Helminth eggs	<1/L -10/L	<0.1/L - 5/L	
Viruses	<1/L -10/L	<1/50L	
Heavy metals	- - -	2 <0.001 mg Hg/L 3 <0.01 mg Cd/L 4 <0.1 - 0.02 mg Ni/L	Specific elements (Cd, Ni, Hg, Zn, etc) are toxic to plants and maximum concentration limits exist for irrigation
Inorganics	- - -	>450 mg TDS/L	High salinity and boron (>1mg/L) are harmful for irrigation
Chlorine residual	- - -	0.5 mg Cl/L - >1 mg Cl/L	To prevent bacterial re-growth. Excessive amount of free chlorine (>0.05) can damage some crops.
Nitrogen **Phosphorus** **Sour**	10 - 30 mg N/L 0.1 - 30 mg P/L	<1 - 30mgN/L <1 - 20 mg P/L	Fertilizer for irrigation. Can contribute to algal growth, corrosion (N-NH4), scale formation (P).

Source: Lazarova, 2001; Metcalf and Eddy, 2003; Pettygrove and Asano, 1985

Table 1.11 Quality Specifications of the Treated Effluent for Crop Irrigation- Regulation KDP 379/2015

Parameter	All Crops and Green Areas with Restricted Use (a)	Green Areas and Cooked Vegetables (b)	Green Areas with Restricted use by the Public	Fodder Crops	Industrial crops	Frequency of analyses
BOD5 (mg/l)	10 mg/lt	10 mg/lt	25 mg/lt	25 mg/lt	25 mg/lt	1/month
COD (mg/l)	70 mg/lt	70 mg/lt	125 mg/lt	125 mg/lt	125 mg/lt	1/month
Suspended solids SS (mg/l)	10 mg/lt	10 mg/lt	35 mg/lt	35 mg/lt	35 mg/lt	1/month

Parameter	All Crops and Green Areas with Restricted Use (a)	Green Areas and Cooked Vegetables (b)	Green Areas with Restricted use by the Public	Fodder Crops	Industrial crops	Frequency of analyses
Fat and oil (mg/l)	5 mg/lt	5 mg/lt	5 mg/lt	5 mg/lt	5 mg/lt	1/ month
E. Coliforms	5 E.Coli /100 ml	50 E.Coli /100 ml	200 E.Coli /100 ml	200 E.Coli /100 ml	200 E.Coli /100 ml	1/month
pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	1/month
Conductivity (µS/cm	2500 µS/cm	2500 µS/cm	2500 µS/cm	2500 µS/cm	2500 µS/cm	1/month
Chlorides (mg/l)	300 mg/lt	300 mg/lt	300 mg/lt	300 mg/lt	300 mg/lt	1/year
Boron (mg/l)	1 mg/lt	1 mg/lt	1 mg/lt	1 mg/lt	1 mg/lt	1/year
Residual Chlorine (mg/l)	2 mg/lt	2 mg/lt	2 mg/lt	2 mg/lt	2 mg/lt	1/month

Cyprus Regulation K.D.269/2005 specifies the reclaimed water quality criteria produced from agglomerations with less than 2,000 population equivalent. Table 1.12 below summarises the tiered approach valid for different irrigation applications.[31]

Table 1.12 Quality Specifications of the Treated Effluent for Rural Agglomerations < 2000 p.e.- Regulation KDP 269/2005

	Crops to be Irrigated	BOD5 (mg/l)	Suspended Solids (mg/l)	E. Coli /100ml	Intestinal Worms***	Treatment required
1	All Crops and Green Areas with Restricted Use (a)	10*	10*	5* 15**	NIL	Tertiary and disinfection
2	Green Areas and Cooked Vegetables (b)	10* 15**	10* 15**	50* 100**	NIL	Tertiary and disinfection
3	Green Areas with Restricted use by the Public	20* 30**	30* 45**	200* 1000*	NIL	Secondary, disinfection and storage >7 days or Tertiary and
4	Fodder Crops	20* 30**	30* 45**	1000* 5000**	NIL	Secondary, disinfection and storage >7 days or Tertiary and
5	Industrial crops	50* 70**		3000* 10000**	-	Secondary and Disinfection

* 80% of the samples, 24 samples/year
** Max acceptable value
*** sampling frequency once a year/summer months
(a) No vegetables with leaves, bulbs and condyles eaten raw
(b) Potatoes, Beetroots

For agglomerations of more than 2,000 population equivalent (p.e.), the quality characteristics that must be met for the use of the treated effluent are specified within the Wastewater Discharge Permits, issued by the Ministry of Agriculture for the Sewerage Boards and the Water Development Department. The values are presented in Table 1.13.

[31] Water Reuse in Cyprus, Iacovos Papaiacovou and Constantia Achileos, Ioanna Ioannidou, Alexia Panayi, Christian Kazner, and Rita Hochstrat -Cyprus-Irrigation- 2012 Guidelines for Water Reuse

Table 1.13 Quality Characteristics and Frequency of Controls of the Treated Effluent for Urban Agglomerations- according to Discharge Permit

Parameter	Maximum permitted value	Frequency of analyses – by WDD	Frequency of analyses – by USB
BOD5 (mg/l)	10 mg/lt	4/year	1/15 days
COD (mg/l)	70 mg/lt	4/year	1/15 days
Suspended solids (mg/l	10 mg/lt	4/year	1/15 days
Conductivity (μS/cm	2200 μS/cm	4/year	1/15 days
Total Nitrogen (mg/l)	15 mg/lt	4/year	1/15 days
Total Phosphorous (mg/l)	10 mg/lt	4/year	1/15 days
Chlorides (mg/l)	300 mg/lt	4/year	1/ month
Fat and oil (mg/l)	5 mg/lt	4/year	1/ month
Zinc (mg/l)	1 mg/lt	2/year	2/year
Copper (mg/l)	0.1 mg/lt	2/year	2/year
Lead (mg/l)	0.15 mg/lt	2/year	2/year
Cadmium (mg/l)	0.01 mg/lt	2/year	2/year
Mercury (mg/l)	0.005 mg/lt	2/year	2/year
Chromium (mg/l)	0.1 mg/lt	2/year	2/year
Nickel (mg/l)	0.2 mg/lt	2/year	2/year
Boron (mg/l)	1 mg/lt	2/year	2/year
E. Coliforms	5 E.Coli /100 ml	4/year	1/15 days
Eggs of intestinal worm	Nothing/lt	4/year	4/year
Residual Chlorine (mg/l)	1 mg/lt	4/year	1/15 days
pH	6.5-8.5	4/year	1/15 days

The prevailing treatment technology until recently was conventional activated sludge treatment with secondary clarifiers followed by sand filtration and chlorination. However, most new projects under planning (new wastewater treatment plants as well as extension of existing ones) are considering advanced technologies such as membrane application, e.g. bioreactor technology (Larnaca, Limassol, and Nicosia) or reverse osmosis. [32]

According to the Law, sewage treatment is of Tertiary Degree, which is higher than the requirements of Directive 91/271/EEC. Tertiary Treatment consists of:

- Activated Sludge with Sand Filtration and Chlorination;
- Membrane Bioreactor with UV Disinfection (2 Urban WWTPs);
- Tertiary treatment is mandatory irrespective of its use in irrigation, recharge of aquifers or disposal to the sea, in order to:
  - Eliminate the possibility of any health incident including pathogens in the treated water;
  - Reduce the risk of possible eutrophication when discharging to the eastern Mediterranean Sea, the most oligotrophic sea in the world; and
  - Reduce farmers skepticism and barriers to reusing – Encourage public acceptance – enhance marketability of crops.

The new Regulation K.D.379/2015 includes the water quality standards for wastewater reuse and is prohibiting the irrigation of treated wastewater for vegetables that are consumed raw, crops for exporting, and ornamental plants. Water quality standards for vegetables that are consumed cooked and other crops

[32] Water Reuse in Cyprus, Iacovos Papaiacovou and Constantia Achileos, Ioanna Ioannidou, Alexia Panayi, Christian Kazner, and Rita Hochstrat -Cyprus-Irrigation- 2012 Guidelines for Water Reuse

are stricter than the WHO guidelines, but less stringent than the US EPA guidelines. Table 1.14 presents the maximum allowable value and compares the values with WHO and USEAP.

Table 1. 14 Comparison of Cyprus standards with WHO and USEPA

Parameters	WHO		USEPA		Cyprus	
E. Coliform (/100 mL)	Unrestricted	E. coli (cfu) ≤ 1000	Food crops	ND FC (median)	Cooked vegetables	E. coli (cfu) ≤ 5
	Restricted	E. coli (cfu) ≤ 10,000	Processed food crops	FC (cfu) ≤ 200 (median)	Crops for human consumption	E. coli (cfu) ≤ 50
Turbidity (NTU)			Food crops	≤ 2 (average)		
rbidity (NTU)			Processed food crops	TSS<3		
Suspended solids (mg/L)			Food crops	≤ 10	Cooked vegetables	≤ 10
Suspended solids (mg/L)			Processed food crops	≤ 30	Crops for human consumption	≤ 10
BOD (mg/L)			Food crops		Cooked vegetables	≤ 10
BOD (mg/L)			Processed food crops		Crops for human consumption	≤10
Intestinal nematodes (No./L)		≤ 1				
pH	5.8–8.5		6.0–9.0			6.5-8.5

ND = not detected;
TC = total coliform;
FC = fecal coliform;
TSS = total suspended solids.

1. Standards for direct wastewater reuse.
2. The most stringent verification monitoring level, which refers to what has previously been referred to as effluent guideline levels, for each irrigation type and arithmetic mean value.
3. For vegetables eaten raw is not allowed and maximum value allowed.
4. Maximum monthly averages for unrestricted irrigation.
   (a) Vegetables whose edible parts are in close contact with the irrigated soil are not included and drip irrigation can be only employed.
   (b) No recommendation.
   (c) In accordance with wastewater treatment standards.

The collection of samples is conducted for chemical and microbiological analyses, toxicity tests and metal ion analyses of samples from 28 Wastewater Treatment Plants, and from the Wastewater Treatment Plants of Sewerage Boards of Nicosia, Larnaca, Limassol, Paphos and Paralimni - Ayia Napa. It includes: [33]

- Sample taking for chemical and microbiological water tests takes place from the Polemidhia Dam, before and after the period when recycled water was discharged in it;
- Sample taking for chemical and microbiological analyses of Ovgos River takes place before and after the discharge period of recycled treated wastewater in the river;
- Sample taking for chemical analyses :
  - Soil irrigated with recycled treated wastewater of the Wastewater Treatment Plants of Sewerage Boards of Nicosia, Larnaca, Limassol, Paphos and Paralimni - Ayia Napa and of the Central Domestic and Industrial Wastewater Treatment Plant at Vathia Gonia; and
  - Sea from Limassol and Larnaka sea before and after the discharge of recycled treated wastewater in the sea, of soil on which sludge from the Central Domestic and Industrial Wastewater Treatment Plant at Vathia Gonia was disposed and of untreated wastewater from almost all the Wastewater Treatment Plants.

The set-up of the food technology laboratory has been implemented at a satisfactory level since 2011. The antioxidant and antimicrobial properties (in vitro and in vivo) of natural products such as essential oils and

[33] WDD_http://www.moa.gov.cy/moa/wdd/wdd.nsf/All/0C2D1E1836A2F4FCC2257CE7002C8173/$file/Etisia_en_2013.pdf?OpenElement

plant extracts are investigated. Moreover, the effect of food processing on product nutrient and anti-nutrient content is a part of a continuous research activity. Finally, the impact of treated waste water use on the microbial load of fruits and vegetables is being investigated.

1.4 Agricultural irrigation: baseline

Agricultural sector profile

Yearly water needs of agricultural activity amounts to an average of 178.5 Mm³; however, as this demand is rarely satisfied, the actual water consumption in agriculture varies accordingly (around 150 Mm³/year), representing around 60% of Cyprus' water consumption. Of these approximately 150 Mm³/year, around 132 Mm³/year are used by irrigated agriculture. Irrigated agriculture represents approximately 28% of the total area under crops.

Crop production in Cyprus is affected by the hot and dry climate which is exacerbated by climate change. These changes pose an important concern for the agricultural sector. Over the past 50 years, Cyprus has made important investments in the agricultural sector, through the establishment of dams and irrigation networks and technical and financial support for the installation of modern irrigation systems. However, the country is facing new challenges caused by climate-induced reductions in water resources and increasing water prices.

The crops under permanent irrigation in Cyprus are:

- Citrus (27% of water consumption);
- Olives (20.2% of water consumption);
- Other deciduous crops (13.5% of water consumption); and
- Others (i.e. avocado, bananas, walnut, fig, grape and pistachio).

The crops under seasonal irrigation are:

- Potatoes (10.8% of water consumption);
- Forage crops (7.9% of water consumption); and
- Vegetables, melon, legume, greenhouse crops and strawberries.

The main non-irrigated crops are wheat, carobs and other forage crops. Table 1.15 presents the main types of crops being cultivated in Cyprus.

Table 1.15 Main types of crops cultivated in Cyprus

	Ha	% of UAA
Land use	118,400	100.0
Arable land	84,870	71.7
Cereals	33,280	28.1
Pulses (total)	670	0.6
Potatoes	4,170	3.5
Industrial crops (total)	100	0.1
Fresh vegetables, melons, strawberries	3,980	3.4
Flowers and ornemental plants (total)	90	0.1
Fodder crops	32,860	27.8
Seeds and seedlings	0	0.0
Other crops on arable land	260	0.2
Fallow land - total (with and w/o subsidies)	9,470	8.0
Kitchen gardens	40	0.0

	Ha	% of UAA
Permanent grassland and meadow	2,140	1.8
Pasture and meadow	1,230	1.0
Rough grazings	780	0.7
Permanent grassland and meadow - not used for production, eligible for subsidies	130	0.1
Permanent crops	31,340	26.5
Fruit and berry plantations	6,970	5.9
Citrus plantations	3,760	3.2
Olive plantations	11,640	9.8
Vineyards	7,620	6.4
Nurseries	50	0.0
Other permanent crops	1,290	1.1
Area irrigated in the previous 12 months	**Hectares**	
olive plantations	8,340	
fruit and berry plantations	6,740	
other crops on arable land	4,740	
potatoes	4,570	
citrus plantations	4,350	
cereals (excl. maize and rice)	1,920	
vineyards	1,680	
fresh vegetables, melons, strawberries - open field	800	
other agricultural land	950	

The recent AGWATER project[34] used a daily crop water balance model to assess changes in irrigation water demand due to climate change and the effect of moisture constraints due to limited rainfall on rainfed crops. In addition, modelling studies indicate that increased temperature will have a negative effect of crop yields in the Mediterranean region[35]. The increasing summer temperatures and increased ozone levels could severely constrain the production of irrigated vegetables and greenhouse crops during the summer months in Cyprus.

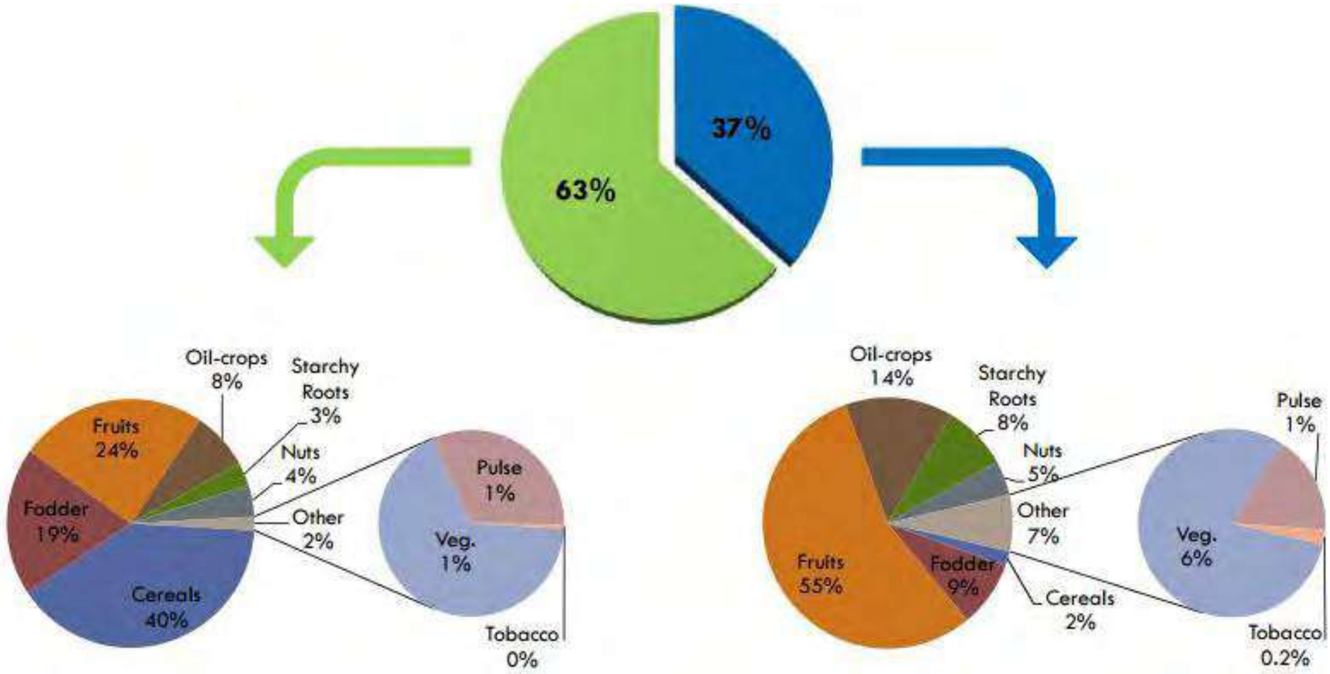
The Cyprus Blue-Green model[36] computes crop water use and has been modified to compute all irrigation requirements (blue water) and rain water use (green water), using the high resolution digital datasets developed by the AGWATER project. The model computes the crop water use per crop plot. The geographic coordinates of the plot are used to identify the plot's soil texture and depth from the digital soil maps. The model then uses a daily time step to compute crop development, water use and yield reductions, both for irrigated and rainfed conditions, for a 30-year period. The results found that areas classified as arid in the western Mesaoria plain will expand and the sub-humid areas in the mountains will contract.

Figure 1.6 presents crop water uses for the 1995-2009 period.

- Blue water refers to the "usable" remainder of the incoming precipitation, which flows in streams and is stored in lakes, dams or aquifers; nd
- Green water originates from precipitation and refers to the water stored in the soil as soil moisture, which returns to the atmosphere as evapotranspiration.

[34] *The Effect of Climate Change on Crop Production in Cyprus – The Cyprus green-blue water model and scenario modelling AGWATER Options for sustainable agricultural production and water use in Cyprus under global change Scientific " (2015)*
[35] Supit et al., 2012
[36] The base model has been described by Bruggeman et al. (2011).

Figure 1.6 Overview of water use per crop type in 1995-2009 period



Source: Zoumides et al. (2012)[37]

Agricultural irrigation

In Cyprus, the current objective is to replace 40% of agricultural freshwater requirements by reclaimed water.[38] The key statistics for irrigation are as follows[39]:

- The percentage of water demand for permanent and annual crops is 59% and 41%, respectively. This accounts for 95.8 Mm^3/year and 65.5 Mm^3/year;
- Out of the 35,100 hectares of irrigated crops, 19,100 are for temporary crops, and 16,000 refer to permanent crops;
- The main irrigated temporary crops are vegetable and melons (28%), followed by fodder crops (13%) and cereals (11%); and
- The main irrigated permanent crops are citrus (15%) followed by fresh fruits (10%), olives and carobs (9%) and Vines (7%).

Modern irrigation systems have been used in Cyprus agriculture for the last 30 years. Due to the relatively high installation cost, the drip method was initially used for irrigation of high value crops, such as greenhouse vegetables and flowers. At a later stage the installation cost was reduced, and the use of drippers, mini sprinklers and low capacity sprinklers was expanded for irrigating trees and field vegetables. Proper hydraulic design of the irrigation systems, offered free of charge by the Ministry, coupled by a subsidy of the installation cost, resulted in a rapid expansion of the new irrigation systems. Farmers have extensively adopted modern irrigation systems.

Irrigation techniques are selected based on the crops:

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[37] The Effect of Climate Change on Crop Production in Cyprus – The Cyprus green-blue water model and scenario modelling AGWATER Options for sustainable agricultural production and water use in Cyprus under global change Scientific Report 8, Deliverable 23, Adriana Bruggeman, Christos Zoumides and Corrado Camera Energy, Environment and Water Research Center, The Cyprus Institute, Nicosia, 31 July 2015
[38] Reuse of Treated Efflent in Cyprus, Presentation, Brussels March 2015, Panayiota Hadjigeorgiou Senior Executive Engineer, Water Development Department Ministry of Agriculture
[39] Agricultural Statistics, 2002

- For densely spaced field vegetables like potatoes, carrots and beans the permanent low capacity sprinkler system is recommended for irrigation. However, in case of limited financial resources, the portable sprinkler system can be used instead, although it requires more labour;
- Drip irrigation is the only applicable method for irrigation of low vegetables grown in greenhouses, low-tunnels and in the open field, spaced at a relatively great distance on the row and between rows. One nozzle is usually installed to deliver water to each plant. Among permanent plantations, drippers are mainly recommended for banana, grapes and several other crops, like aromatic plants. Generally, unless there is a particular problem, drippers with larger nozzle opening are preferred, because they are not easily blocked by impurities; therefore, they require less filtering and they are characterized by higher uniformity in low; and
- For irrigation of permanent tree plantations both drippers and mini sprinklers can be successfully used. No differences have been observed concerning crop development and production; therefore, the choice of the irrigation method depends on several other factors. Mini sprinklers are generally preferred and are more widely used for irrigation of trees, mainly due to lower installation cost. Moreover, as nozzle opening is relatively large, they are not easily blocked by impurities present in the irrigation water.

The introduction of modern irrigation systems in Cyprus resulted in the expansion of irrigated agriculture, increase of water use efficiency and production, and improvement of yield quality.

Table 1.16 presents the annual quantities of treated water from waste water treatment plants and the related use (irrigation, aquifer recharge or discharge into the sea).

Table 1.16 Yearly quantities of treated effluent per plant (2012) [40]

Wastewater treatment plant	Quantities (m3)	Irrigation (water reuse)	Enrichment of aquifer	Discharged into the sea	Irrigation is done under the code of correct agricultural practice
Mia Milia (Nikosia)	10.950.000	10.950.000			Depending on the type of crop rotation strategy, approximately 500 hectares can be irrigated with treated water
Limassol	7.474.700	4.308.650		2.970.510	Citrus trees Fodder crops Vegetables Green areas Vines
Paphos	3.909.953	91.250	3 3.818.703		
Ayia napa	1.002.011	1.002.011			Citrus trees Olive trees Potatoes Green areas
Paralimni	1.678.491	1.678.491			
Larnaka	2.583.455	1.921.655		661.800	Citrus trees Fodder crops Green areas Corn
Anthoupolis	1.137.315	366.389			Citrus trees Fodder crops Vegetables Vines
Vathia gonia (wdd)	171.240	171.240			Green areas Corn Olive trees Fodder crops Grass production
Vathia gonia (sbn)	2.251.718	2.251.718			

40 WDD, Presentation, Lia Georgiou, Senior Sanitary Engineer – Sewage and Reuse Division- 05/03/2015

Wastewater treatment plant	Quantities (m3)	Irrigation (water reuse)	Enrichment of aquifer	Discharged into the sea	Irrigation is done under the code of correct agricultural practice
Total production from WWTP (A)	**20.208.883**	**11.791.404**	**3 3.818.703**	**3.632.310**	
Refugee housings	277.400	277.400	0	0	
Hospitals	467.200	467.200	0	0	
Small communities < 2.000 p.e.	237.250	237.250	0	0	
Military camps	249.660	249.660	0	0	
Rural communities > 2.000 p.e	770.150	770.150	0	0	
Total production from smaller infrastructure (b)	**2.001.660**	**2.001.660**	**0**	**0**	
Grand total (a) +(b)	22.210.543	13.793.064	3 3.818.703	3.632.310	

Costs for construction and operation of municipal wastewater collection and treatment infrastructure are funded by the local communities through the sewerage rates. Tertiary treatment and reclaimed water distribution networks are financed and operated by the government, through the WDD. Customers are charged different prices for reclaimed water depending on the end use. The table below presents the prices charged based on the use.

Table 1.17 demonstrates the current pricing structure in Cyprus, which currently reuses nearly all of its reclaimed water.

Table 1.17 Selling rates of the treated effluent

	Use	Tertiary Treated Effluent	Fresh not filtered water from government water works
		€ m^3	€ $/m^3$
1	For Irrigation divisions for agricultural production	0.05	0.15
2	For Persons for agricultural production	0.07	0.17
3	For sports	0.15	0.34
4	For irrigation of hotels green areas and gardens	0.15	0.34
5	For pumping from an aquifer recharged by the treated effluent	0.08	
6	For over consumption for the items 1 to 5	Increase by 50%	0.56

Source: WDD, 2008 costs

Reused water tariffs in Cyprus range from 33%-44% of freshwater rates, ratios which appear typical for the EU Mediterranean islands[41]. The price reflect the imposition of substantial subsidies to reclaimed water supplies to encourage wider uptake, [42] which may be at odds with the need for greater cost recovery in water treatment and management. Although such subsidised price structures have been in place for many years to

[41] Hidalgo & Irusta, 2005

42 BIO_IA on water reuse_Final Part I.pdf

incentivise take-up, price rates are usually based on intuitive judgements by utilities of the level of willingness to accept reclaimed supplies amongst different groups rather than empirical evidence of the price at which users would begin to accept these supplies over conventional freshwater. [43]

In Cyprus, rates for reused water were until recently set at 100% of freshwater rates. Increases in freshwater pricing in recent years have lowered the relative cost of reused water, whilst strong pollution abatement regulations have also increased the overall capacity of treated effluent supplies. Comparison with uptake levels in 2005 indicates a relatively inelastic demand within the agricultural sector, attributed to distribution and infrastructure constraints, but noticeable elasticity of demand for uses in landscape irrigation (sports, hotels and gardens). [44]

1.5 Agricultural irrigation: proposal

The key differences between the JRC proposal (April 2016 version) and the Cypriot standards are as follows:

- Both follow a different conceptual structure, which places emphasis on risk management and risk assessment. The JRC introduces the concept of multiple barriers-preventive measures (e.g. wastewater treatment, on-farm management) leading to log reductions of risk for public health.
- The scope of the JRC standards includes viruses, protozoa and bacteria, whereas Cypriot standards only cover bacteria (i.e. *E. Coli*). It is interesting to note that the JRC recognises the growing issue of antibiotic resistant bacteria, by adding tetracycline or cefotaxime resistant *E. Coli* among the monitored parameters. Almost all of the other parameters are already covered by the Cypriot standards.
- Cypriot standards for food crops to be eaten raw also require secondary treatment, advanced treatment and disinfection and the minimum threshold values for all monitored parameters are stricter than those of reclaimed water quality A in the JRC proposal.
- Cypriot standards for food crops to be cooked or processed already require secondary treatment and disinfection, and the minimum threshold values are stricter for *E. Coli* than those of reclaimed water quality B in the JRC proposal.
- The JRC standards also provide a scenario of less stringent wastewater treatment (no disinfection) for food crops heavily processed, well-cooked or having no contact to the ground (e.g. grapes for wine production, cereals, potatoes, beetroots, fruit trees). Cypriot standards for non-food crops require secondary treatment and disinfection and the minimum threshold values are much stricter than those of reclaimed water quality C.

Policy Option Ag. 2 – Guidance/Recommendation (non-binding)

The Cypriot standards are generally stricter than the JRC proposal. In addition, the framework included in the JRC proposal is not simpler than for Cyprus. In some extent, the Cypriot standards can be considered more easily understandable, as they contain less categories and reference tables.

Cyprus would be expected to keep its own legal framework.

Policy Option Ag. 3 – Regulation (binding)

This policy option introduces a legally binding document setting out quantifiable minimum water quality requirements that must be complied with when using reclaimed water in agricultural irrigation. It includes

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43 BIO_IA on water reuse_Final Part I.pdf

44 Guidance on the Use of Reclaimed Water - Research works carried out by the University of Cyprus, presented during the CIS PoM working group meeting of 25/03/14 - Reuse of Treated Effluent in Cyprus, Panayiota Hadjigeorgiou Senior Executive Engineer, WDD

specifying eligible sources of wastewater that can be used for irrigation and risk management measures that must be complied with.

The Cypriot standards are generally stricter than the JRC proposal but the legal binding of the proposal may reduce farmers' skepticism and enhance marketability of crops.

Establishing a common understanding and harmonizing different standards across European Countries may provide a guidance on the safe use of reclaimed water and encourage public acceptance.

1.6 Agricultural irrigation: assessment of key impacts

Policy Option Ag. 2 – Guidance/Recommendation (non-binding)

The situation in Cyprus will look similar to the baseline, as Cyprus will keep a similar legal framework to the existent. The costs for monitoring and treatment will be similar to the current.

Public acceptance is expected to be positively affected after the publication of the instrument, but only to a limited degree.

It is not expected that this development will be broadly communicated or discussed in depth.

Policy Option Ag. 3 – Regulation (binding)

The situation in Cyprus will develop quite similarly to the baseline, but there will be some key differences, which will affect the uptake of wastewater reuse positively.

The introduction of a common instrument for all EU countries would improve the public acceptance of water reuse and enhance public confidence in consuming products irrigated with reuse water.

The key impacts of such option are presented below:

- Key economic impacts: The agricultural sector and the food industry, which highly depend on water supply, will increase their resilience against water scarcity, droughts and climate change;
- Key social impacts: The establishment of an EU regulation together with improved communication on actual risks and benefits of water reuse is expected to have a positive impact on confidence of the general public in the quality of the reused water and, therefore, on acceptance of water reuse as a water management tool;
- Key environmental impacts: Reduced pressure on water resources. Positive contribution to the quality of water resources (e.g. reduced impact of waste water discharge on sensitive rivers, reduced risk of saline intrusion in over-exploited coastal aquifers). The impact on soil will depend on the option and quality parameters considered in the requirements: while the presence of some nutrients and organic matter in treated wastewater can be beneficial to enhance soil fertility and crop production, the presence of other elements (e.g. salts, micropollutants) may be detrimental, as well as impacting on the wider environment. Reuse of treated wastewater for irrigation can decrease the level of purification/treatment necessary for discharge and thus reduce energy consumption and costs associated with water treatment;
- Key impacts on public administration and administrative burden: Given the different conceptual structure of the proposed framework versus the current Cypriot framework and the conceptual innovations it introduces, the additional effort by administrations is expected to high. Given the complexity of the proposed framework the administrative burden for national developers and beneficiaries of water reuse projects will be impacted neutrally or negatively. However, the increased consistency across the EU is expected to result in a reduction of the administrative burden.
- Key impacts on SMEs: Impacts on SMEs are expected to be positive as they will benefit from an increased and/or better secured access to water. Agricultural businesses, which are the largest consumer of freshwater in Cyprus, are likely to be particularly influenced;

- Key impacts on competitiveness and innovation: Impacts on competitiveness and innovation are expected to be positive. Removal of present barriers to investments is expected. A clear and consistent EU framework would allow economies of scale and standardization. This in turn would support innovation and development of solutions at lower costs; and
- Key impacts on third countries, international trade or investment: Considering that water reuse is an emerging worldwide market, a greater uptake of reuse at the EU level would provide a showcase for the relevance of these technologies and skills of EU companies towards potential customers in third countries. The trade of agricultural goods irrigated with reclaimed water would be positively influenced.

1.7 Agricultural irrigation: Comparison of the alternative policy options

Cyprus is a water stressed country and it needs water reuse. The need for water has made Cyprus to become a leader in water reuse. Cyprus has adopted effective water policies and its legislation is not only based on the promotion of water use but on measures for water saving and water quality protection.

The legally binding option provides better improvement of public perception and raising confidence, removes the fragmented approaches for agricultural irrigation using reuse water across Europe and implies lower treatment costs.

Therefore, the legally binding instrument would present more benefits than a non-legally binding instrument.

1.8 Aquifer recharge: baseline

In Cyprus almost all the aquifers are over-exploited and for many of them, water quality has deteriorated due to seawater intrusion. Drastic action is required for reducing aquifer extraction to a level, which will allow the aquifers to recover.[45]

Two methods have been identified as suitable: the drastic reduction of abstraction to sustainable levels and the increase of aquifer recharge with natural and artificial methods. Managed Aquifer Recharge (MAR) is becoming an increasingly attractive water management option, especially in semiarid areas. Nevertheless, field studies on the fate and transport of priority substances, heavy metals and pharmaceutical products within the recharged aquifer are rare.

Groundwater resources

In Cyprus, groundwater is under strong human pressures including changes in land use, urbanisation, intensive agriculture and water demand increase. The pressures cause severe degradation of the quality and quantity of groundwater resources. Groundwater resources in Cyprus are overexploited by about forty percent of sustainable extraction. During the last 15 to 20 years many of the aquifers' water balance have been permanently altered. Most of the aquifers in the island are phreatic aquifers developed in river or coastal alluvial deposits. These are the biggest and the most dynamic aquifers mainly replenished from river flows and rainfall. During the last decade almost all aquifers, exhibited depleting trends. Some of the coastal aquifers have even shown water levels below sea level.[46]

In Cyprus, both surface water and groundwater resources are intensively used for water withdrawal. Whilst the use of surface water resources is managed by the WDD, the abstraction of groundwater is less well

[45] Management Of Groundwater Resources In Cyprus - Harmonization With The EU Water Framework Directive, Charalambos Demetriou and Adonis Georgiou, WDD,2004

[46] Management Of Groundwater Resources In Cyprus - Harmonization With The EU Water Framework Directive, Charalambos Demetriou and Adonis Georgiou, WDD,2004

administered. As a result, the number of boreholes is estimated to exceed 50,000 a considerable number of which is illegal with uncontrolled abstraction. .[47]

Characterising water bodies according to requirements of the Water Framework Directive, around 80% of the groundwater bodies had been assessed as being at risk of failing to achieve a "good status" by 2015. This is mainly due to over-pumping, saltwater intrusion and high nitrate concentrations caused by agricultural activities.[48]

Frequent and long lasting droughts over the last decades have reduced the direct and indirect groundwater recharge. It has been exacerbated by the construction of dams on the major rivers of the country, which before were recharging downstream aquifers. At the same time farmers, in their effort to maintain agricultural production levels, have continued extracting the same quantities of groundwater and in most cases have even increased abstraction. All these conditions have resulted in saline water intrusion and both the quality deterioration of coastal aquifers and the depletion of inland aquifers.[49]

Besides its growing scarcity, groundwater is also being abandoned for use in the domestic supply because of quality problems. Intensive agriculture and excessive use of fertilisers have resulted in nitrate pollution of many aquifers. Similarly nitrate pollution problems appear in aquifers near inhabited areas because of direct sewage disposal in adsorption pits.

Aquifer recharge

The main environmental issue associated with artificial recharge is the degradation of sub-surface environment and groundwater due to the transport of pathogenic viruses with the recycled water. Furthermore, the clogging effect of boreholes caused by suspended solids, bacterial and recharge water is a phenomenon that limits the viability of artificial recharge.[50]

Artificial recharge of aquifer with treated effluent water can be applied in areas suffering from droughts. The advantages of the recharge include:

- Seawater intrusion is being controlled;
- Provide storage of effluent water for subsequent retrieval and reuse;
- The aquifer serves as an eventual natural distribution system;
- Further purification of effluent water is made (reduce biological load); and
- Saving of equal quantities of fresh water for domestic use.

The process of selecting suitable locations includes: hydrogeological conditions, availability and quality of wastewater, possible benefits, economic evaluation and environmental considerations. The wastewater should be pre-treated to improve its physico-chemical characteristics. The pre-treatment includes ultrafiltration and/or inverse osmosis. Membrane techniques are successful in producing wastewater with low values of TDS and nutrient content.

A study tested the application of artificial recharge in the South-Eastern Mesaoria aquifer, using the reclaimed wastewater produced at the Agia Nappa-Paralimni treatment plant.[51] Over abstraction during the last decades through a large number of boreholes has caused a decline of groundwater level. The average

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[47] Case Study report Cyprus, April 2009, Techneau

[48] MANRE,2005

[49] Management Of Groundwater Resources In Cyprus - Harmonization With The EU Water Framework Directive, Charalambos Demetriou and Adonis Georgiou, WDD,2004

[50] 2011.Artificial Recharge via Boreholes Using Treated Wastewater: Possibilities and Prospects, Kostas Voudouris

[51] The scientific work was carried out by the Aristotle University of Thessaloniki (Laboratory of Engineering Geology and Hydrogeology) in cooperation with LDK ECO Environmental consultants S.A. and Atlantis consultants, in the framework of a research program, funded by the Republic of Cyprus (Ministry of Agriculture and Natural Resources, Department of Water Development)

thickness of the unsaturated zone, below sea level, is 25 m, whereas the average thickness of rocks of the unsaturated zone above sea level is 50 m. The maximum annual recharge volume of the aquifer system through 90 recharge boreholes is estimated to be 3.2×10^6 m3 water.[52] The data from the operation of the Agia Napa Wastewater Treatment Plant (WWTP) shows that there is, in general, surplus of recycled water (260,000 m3/year) in regard to the irrigation and/or other needs of the two communities. The maximum daily capacity of WWTP is 21,000 m3. The results of the test study demonstrated the feasibility of artificially recharging the aquifer system of Liopetri area (Cyprus), via deep boreholes, using pre-treated wastewater.

The Ezousas aquifer provides an example of aquifer recharge with water reuse. It is a confined river aquifer close to the sea in the southern part of Cyprus which delivers groundwater to a number of private wells for irrigation. Due to the decrease of precipitation and the recent building of a dam upstream, there has been a low groundwater table downstream. Additionally, private wastewater recharge that earlier contributed to some extent to local groundwater recharge in the area has ended. To reverse this and since 2004tertiary cleaned wastewater is artificially recharged to the Ezousas aquifer through ponds to increase the amount of available groundwater for irrigation. The water originates from the Paphos sewage treatment plant. The groundwater is mixed with water from the river upstream the dam at a ratio of 1:20 and used for irrigation both locally as well as exported to a neighbouring region. The dominant crop in both areas is citrus trees.

The coastal part of the Ezousas riverbed aquifer, up to 8 km from the coast, is used as a natural reservoir for storage and reuse of the treated water. The recharge is done through shallow ponds and the water level in each pond reaches up to 0.5 m from where it slowly seeps into the ground. Pumping is carried out strategically so that retention time in the aquifer is maximised. Groundwater quality is monitored regularly in accordance with the Discharge Permit.

The proven benefits of Ezousas artificial groundwater recharge are:

- Artificial recharge with effluent water is a good case study, which can be applied in areas with similar geological conditions suffering from droughts;
- Seawater intrusion is being controlled;
- Provide storage of effluent water for subsequent retrieval and reuse;
- The aquifer serves as an eventual natural distribution system;
- Further purification of effluent water is made (reduce biological load); and
- Saving of equal quantities of fresh water for domestic use.

For recharge with treated wastewater, as is the case of the Ezousas riverbed aquifer, costs depend upon the degree of treatment of the source water, the distance over which source water must be conveyed, the stability of recharge structure and resistance to siltation. [53]

Suitability of recharge with indirect potable reuse

One of the difficulties encountered with **indirect potable reuse** concerns the potential genotoxicity and carcinogenicity of trace organic compounds present in effluent organic matter and the fates of those compounds during soil aquifer treatment that have not been adequately established[54]. As a result, treated effluent is usually used for non-potable purposes only, such as agriculture and urban or landscaping irrigation[55]. The possible health risk and public acceptability mean that treated sewage effluent can rarely be used directly in public supply[56].

Indirect use occurs through an ‘environmental buffer’; that is, a natural water body (river, lake, and aquifer) that physically separates the product water from the wastewater reclamation plant. The three perceived

[52] 2011.Artificial Recharge via Boreholes Using Treated Wastewater: Possibilities and Prospects, Kostas Voudouris
[53] WDD, Implementation of Articles 5&6 of the WFD 200/60/EC, 2004
[54] NRC 1998; Bouwer 2002; Quanrud et al. 2003
[55] Bouwer 2002
[56] NRC 1994, 1998; USEPA 2004

benefits of buffers are that they provide (1) an opportunity to further reduce contaminants through natural attenuation processes (2).

1.9 Assessment of impacts

Climate and demographic change, possibly assisted by migration, are expected to increase the pressures on the Mediterranean water resources in the future, thus affecting Cyprus also. Existing issues with water scarcity and drought will deteriorate and the economic activities of farming and tourism are more intense. Demand for water is expected to rise. Water shortages in all sectors and associated economic losses are expected to increase. This will raise concern on water availability and water use efficiency. The use of non-conventional water resources (e.g. wastewater reuse) will attract greater interest in public discussion and scientific research.

The environmental benefits of the aquifer reuse have already been demonstrated by the Ezousas aquifer which is recharged artificially with 2–3 Mm^3 reclaimed effluent per year, which is then re-abstracted for irrigation.

In addition, most recently, the Cyprus WDD used the rapidly depleting Akrotiri aquifer as a storage tank in order to reduce the effects of sea intrusion.

Generally, recycled water for irrigation and recharge purposes is a growing resource in Cyprus.

1.10 Aquifer recharge: proposal

Key differences between the JRC proposal (April 2016 version) and the Cypriot standards

JRC standards refer only to urban wastewater, whereas the Cypriot standards also refer to conventional industrial wastewater.

A review of the proposed standards shows that they are loosely described, missing appropriate detail and clarity. They make references to existing EU water legislation (i.e. WFD, DWD and GWD), which is already adopted by Cypriot legislation.

In the draft version of the JRC proposal, reclaimed water quality for water recharge is distinguished according to the type of aquifer being recharged. The two categories of water are:

- Recharge of aquifers which are *used as a potable water source* (DWD, GWD, WFD); and
- Recharge of aquifers which are ***not*** *used as a potable water source* (GWD, WFD).

Overall, the key differences are the following. The reclaimed water for the potable aquifer recharge will comply with DWD, GWD and WFD, whereas for non-potable aquifer recharge compliance with the DWD will not be needed. Another new element in the JRC proposal is the possible inclusion of contaminants of emerging concern (CECs) (e.g. biocides, hormones, pharmaceuticals, personal care products) for monitoring before potable or non-potable aquifer recharge. Such substances are not included in the Cypriot standards. It is important to highlight that both standards require a hydrogeological study to be conducted to specify the local recharge scheme.

For potable aquifers the JRC proposal stipulates stricter limits, following the DWD. Since the Cypriot standards already require secondary, advanced treatment (membranes) and disinfection the additional costs for treatment are not significantly higher.

For non-potable aquifers the JRC standards look simpler and less strict than the Cypriot standards. Cypriot standards for non-potable water require secondary treatment and disinfection or secondary, advanced treatment and disinfection. Implementation of the JRC standards for non-potable water means higher cost for monitoring and lower cost of treatment. The total cost is assumed similar to the Cypriot standards.

Policy Option Aq. 2 – Guidance/Recommendation (non-binding)

This policy option introduces a non-legally binding document stipulating minimum quality requirements for using reclaimed wastewater for aquifer recharge. Specified water quality standards are determined based on the end-use, i.e. whether the aquifer is used as a source of potable water or non-potable water.

Different end-uses require different levels of protection (with environmental compliance standards as a minimum), i.e. the standards proposed will not compromise the objectives and requirements of GWD, WFD and DWD.

The Cypriot standards differ significantly in concept from the standards proposed by the JRC. They are different regarding the categories of reclaimed water, the monitored parameters and the foreseen level of treatment for each category.

The adoption of the JRC standards would result in higher cost for monitoring and treatment for potable aquifers and similar total cost for non-potable aquifers. Cyprus is expected to keep its own legal framework.

Policy Option Aq. 3 – Regulation (binding)

Legally binding standards are expected to be transposed into national legislation. The public acceptance is expected to be higher. It may have a positive impact on research and innovation because standards will be harmonized. The establishment of Legally Standards would:

- Improve the water resources management and increase protection of public health and environment;
- Encourage the use of alternative water sources;
- Enhance agricultural yield and quality of products all over EU;
- Remove possible barriers in the trade of products;
- Establish a common understanding and harmonize different standards across MS; and
- Set specific quality standards for recycled water and to provide guidance on the safe use of reclaimed water.

1.11 Aquifer recharge: assessment of key impacts

Non-binding standards for water reuse

The situation in Cyprus would look similar to the baseline, as Cyprus will keep a similar legal framework to the existent. Reuse in aquifer recharge has already started.

Public acceptance is not expected to be affected after the publication of the instrument, as it is already high.

Legally binding standards for water reuse

The adoption of wastewater reuse is already high in Cyprus. With the adoption of the binding standards, the situation in Cyprus will look quite similar to the baseline. The main impacts are:

- Key economic impacts: The agricultural sector and the food industry, which highly depend on water supply, will increase their resilience against water scarcity and droughts and climate change;
- Key social impacts: The establishment of this EU framework together with improved communication on actual risks and benefits of water reuse is expected to have a positive impact on confidence of the general public in the quality of the reused water and, therefore, on acceptance of water reuse as a water management tool;
- Key environmental impacts: Reduced pressure on water resources. Positive contribution to the quality of water resources (e.g. reduced impact of waste water discharge on sensitive rivers, reduced risk of saline intrusion in over-exploited coastal aquifers);

- Key impacts on public administration and administrative burden: Given the different conceptual structure of the proposed framework versus the current Cypriot framework and the conceptual innovations it introduces, the additional effort by administrations is expected to high;
- Key impacts on SMEs: Impacts on SMEs are expected to be positive as they will benefit from an increased and/or better secured access to water. Agricultural businesses, which are the largest consumer of freshwater in Cyprus, are likely to be particularly influenced;
- Key impacts on competitiveness and innovation: Impacts on competitiveness and innovation are expected to be positive; and
- Key impacts on third countries, international trade or investment: Considering that water reuse is an emerging worldwide market, a greater uptake of reuse at the EU level would provide a showcase for the relevance of these technologies and skills of EU companies towards potential customers in third countries.

Aquifer recharge: Comparison of the alternative policy options

Both options will not induce further uptake of wastewater reuse of aquifer recharge, but the legal binding standards will perform better in terms of improvement of acceptance

2. France

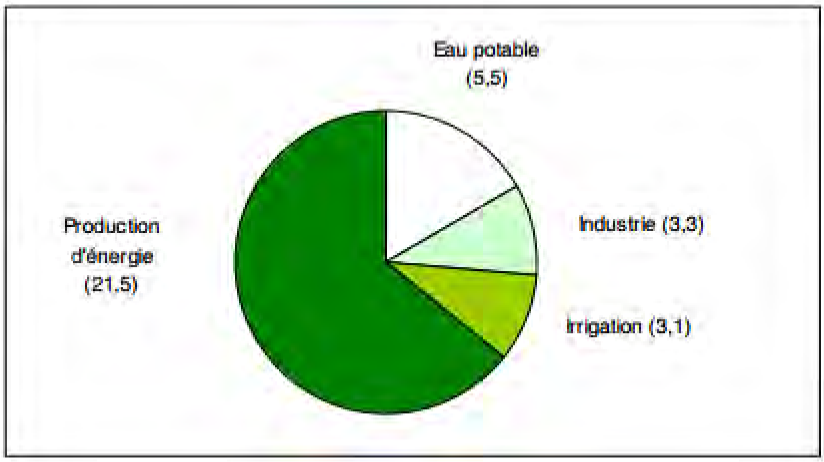
2.1 France: Availability of water reuse with little uptake so far

Overview of water use by sector

Water abstraction

In 2009, 33.4 Mm3 were abstracted in France for all uses (domestic, agriculture, industry and hydropower). 18% of this amount is abstracted from groundwater bodies, whereas the remaining 82% comes from surface water bodies. The share of abstracted water by each sector is presented in the figure below[57].

Figure 2.1 Share of water abstraction by sector in France in 2009 (in Mm3)

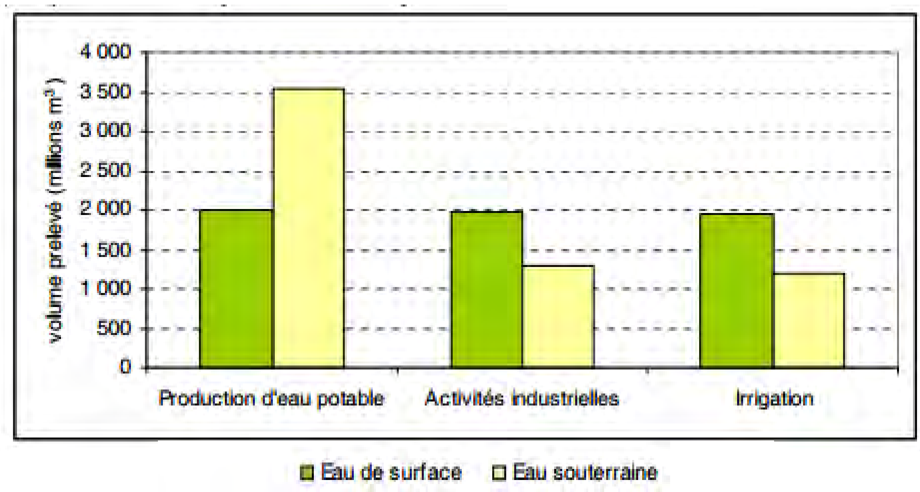


Source: CGDD, 2012

Water used for hydroelectric production is abstracted from surface water bodies, and around 90% of total abstracted water is returned to the environment, so it is appropriate to focus on the volumes abstracted by the domestic, agricultural and industrial sectors: these are shown in the figure below[58].

[57] CGDD, 2012. Les prélèvements d'eau en France en 2009 et leurs évolutions depuis dix ans. Chiffres et statistiques, No. 290, Février 2012. http://www.eaufrance.fr/IMG/pdf/prelevements2009_201202.pdf
[58] CGDD, 2012

Figure 2.2 Water abstraction by sector (domestic, agricultural and industrial sectors only) in 2009



Source: CGDD, 2012

As it can be seen from the graph above, the largest share of groundwater resources is used by the domestic sector.

Overall, water abstraction in France has showed a decreasing trend in the period 2000-2009. The only exception is the agricultural sector: after some years of steady decrease, an increase in abstracted water was recorder between 2008 and 2009[59].

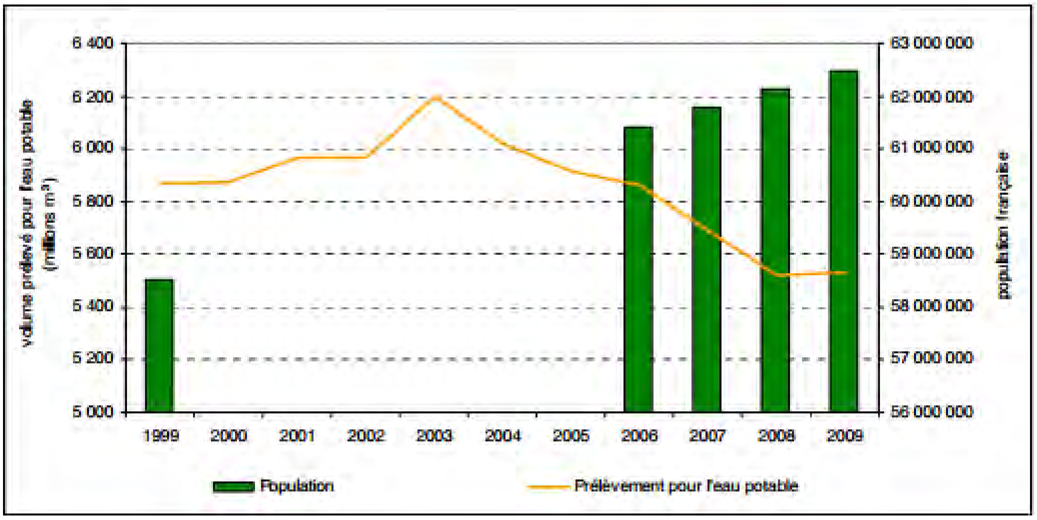
Water use - Domestic sector

Domestic demand is the highest in the regions with high population (e.g. Parisian Region, Provence-Alpes-Côte d'Azur and Rhône-Alpes)[60]. Pollutions coming from this use are mainly organic. Water is mostly collected and treated by plants or a group of municipalities[61]. Overall 99% of the French population was connected to a drinking water supply network in 2004[62].

Water use: 3.5 Bm3 were consumed in 2011 by the domestic sector[63]. Water and sanitation (W&S): W&S services are the responsibility of municipalities. Often municipalities join efforts to provide the service together and reduce the costs. Municipalities can also decide to delegate to private companies. In 2005, 76% of French population was provided by private companies[64]. While the service is performed by a private company, the infrastructure belongs to municipalities[65]. The trend for the 2000-2009 period is presented below.

59 CGDD, 2012
60 http://www.statistiques.developpement-durable.gouv.fr/fileadmin/documents/Produits_editoriaux/Publications/Chiffres_et_statistiques/2012/Chiffres%20et%20stats%20290%20Pr%C3%A9l%C3%A8vements%20d%27eau%20en%20France%20en%202009%20-%20f%C3%A9vrier%202012.pdf
61 O. Bommelaer, J. Devaux, 2012. Le financement de la gestion des ressources en eau en France (actualisation de janvier 2012), Etudes & Documents, SEEIDD CGDD, n°62 Janvier 2012.
62 P. 27 de IOWATer management france
63 http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do
64 FNE, 2008
65 P. 27 de IOWATer management france

Figure 2.3 Water abstraction by domestic sector for 2000-2009 period



Source: CGDD, 2012

Water efficiency: The domestic water supply network has en efficiency rate of 79.7% -which means that about 20% of abstracted water is lost by the network due to leakages[66]. Environmental efficiency: For modern water treatment plants, up to 90% of pollution are removed before putting the water back into the environment[67]. Economic efficiency has been increased thanks to municipalities pooling to provide water services jointly, reducing costs[68].

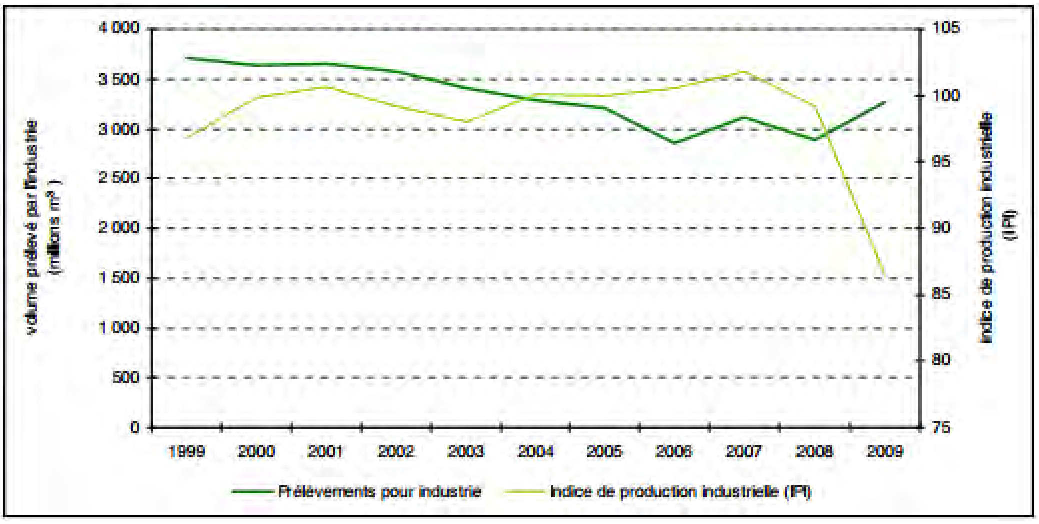
Water use - Industry

According to their size, industries have either their own water treatment system or are using collective services. Water abstraction for the industry is mainly practiced in the East of France, the North, the region around Lyon and the South-West of France which are regions with the largest industries[69].

Water use: 0.36 billion m3 in 2004[70]. 6% of all the water used in France was used by industries this same year[71]. The trends are presented in the figure below.

[66] Observatoire des services publics d'eau et d'assainissement, 2015. Rapport national des donnees sispea – synthese. Edition de juillet 2015 , donnees 2012 http://www.services.eaufrance.fr/docs/synthese/rapports/Rapport_SISPEA_2012_resume_DEF.pdf
[67] FNE, 2008
[68] Bommelaer and Devaux, 2012
[69] http://www.statistiques.developpement-durable.gouv.fr/fileadmin/documents/Produits_editoriaux/Publications/Chiffres_et_statistiques/2012/Chiffres%20et%20stats%20290%20Pr%C3%A9l%C3%A8vements%20d%27eau%20en%20France%20en%202009%20-%20f%C3%A9vrier%202012.pdf
[70] Bommelaer and Devaux, 2012
[71] FNE, 2008

Figure 2.4 Trend of water abstraction for industrial sector irrigation in the period 2000-2009



Source: CGDD, 2012

Water and sanitation: Small and Medium Enterprises and the handcrafted sector mainly use common sanitation system (sometimes after they partly treated the waste water). Larger companies generally own their sanitation system[72].

Water efficiency: Abstraction of water has decreased in past years in Western Europe by 10%. "The decrease is partly because of the general decline in water-intensive heavy industry but also because of increases in the efficiency of water use"[73]. This also applies to France.

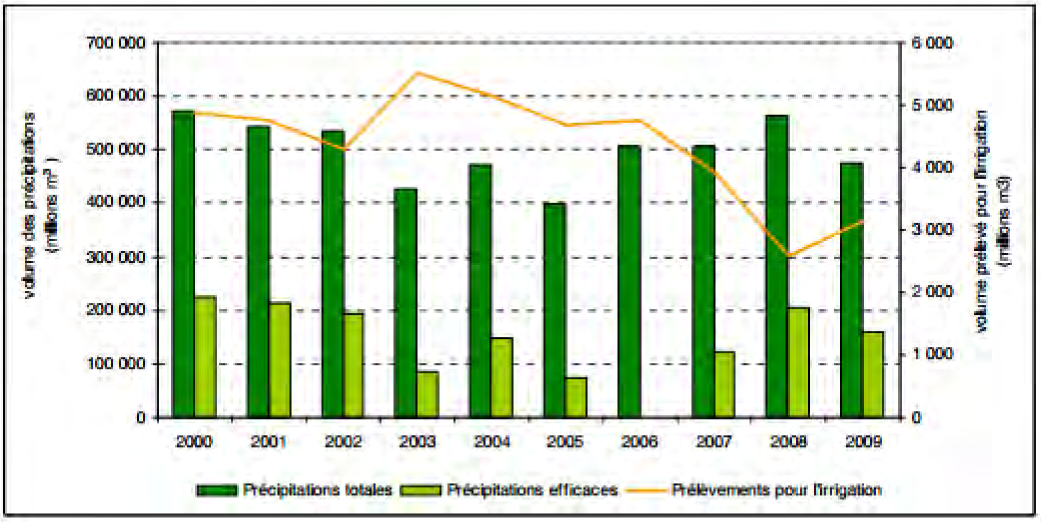
Water use - Agriculture

The level of irrigation vary a lot across France. It depends on what is grown, on the relevance and extension of agriculture in a specific department or region, on the climate and on the irrigation model. The regions where most water is used for irrigation are the south-west, Poitou-Charentes and the Centre[74].

Water use: 3,923 Million m3 were provided for irrigation through supply networks in 2007. Overall, in 2009 agriculture accounted for 26% of the total water abstracted by the domestic, agricultural and industrial sectors, and 9% of the total water abstracted in France (thus including hydropower production)[75]. The trend over the 2000-2009 period is presented below.

[72] FNE, 2008
[73] http://www.eea.europa.eu/publications/environmental-indicator-report-2012/environmental-indicator-report-2012-ecosystem/part2.xhtml#chap8
[74] http://www.statistiques.developpement-durable.gouv.fr/fileadmin/documents/Produits_editoriaux/Publications/Chiffres_et_statistiques/2012/Chiffres%20et%20stats%20290%20Pr%C3%A9l%C3%A8vements%20d%27eau%20en%20France%20en%202009%20-%20f%C3%A9vrier%202012.pdf
[75] CGDD, 2012

Figure 2.5 Trend of water abstraction for agricultural sector irrigation in the period 2000-2009



Source: CGDD, 2012

Water efficiency: Water resource efficiency in this sector is measured by the water abstraction per crop produced. Efficiency has been gained through changes in irrigation systems. In the Cote d'Azur for example a conversion from open channels to pressurized pipe networks helped save around 300 million m3 annually[76].

Water stress and water scarcity

The Water Exploitation Index was above 21% until 1994 but since 2000 it is under 20%, averaging at 15.5% for the period 2008-2012 (Eurostat). France faces a large variety of situations concerning water scarcity and water availability –some regions do not face significant water stress, whereas significant water scarcity can occur in other areas. However, 20 Departments are submitted to regular abstraction restrictions and more than 60 are subject to restrictions at least once a year due to serious droughts (2003, 2005 and 2011)[77]. The analysis of natural flows in France shows that low water periods are more frequent and more serious since the last 40 years (1970-2010), and that particularly in the South of France[78].

The consumption of water for farming is growing strongly in South-Western France and the Paris region in particular, whereas consumption for industry seems to be falling, and domestic consumption has reached a ceiling that now even seems to be slowly declining. In addition to the growing demand for water for agricultural purposes, some irrigated crops (such as corn) have become more widespread and periodical droughts have occurred. Over the last 20 years drought events affected the regions traditionally considered to be the wettest, in Western and North-Western France. In more than one-third of the country, water tables are falling as autumn and winter rains are no longer compensating for the amounts drawn up in spring and summer. Faced with this situation, the authorities have imposed restrictions on water use, which is a very unusual practice in France. It is also worth recalling that around fifteen French departments are situated in an area with a Mediterranean climate similar to that of Northern Spain and Italy, well-suited to market gardening, fruit farming and mass tourism. All of these tend to increase the need for water, at the time when resources are periodically insufficient. However, these departments do not experience serious water shortages because they were equipped with canals bringing water from the Durance and Rhone rivers[79].

[76] http://www.eea.europa.eu/publications/environmental-indicator-report-2012/environmental-indicator-report-2012-ecosystem/part2.xhtml#chap8

[77] INRA, 2006. Amigues J.P., P. Debaeke, B. Itier, G. Lemaire, B. Seguin, F. Tardieu, A. Thomas (éditeurs), 2006. Sécheresse et agriculture. Réduire la vulnérabilité de l'agriculture à un risque accru de manque d'eau. Expertise scientifique collective, synthèse du rapport, INRA (France), 72 p.

[78] ONEMA, 2011. Les impacts du manque d'eau sur les milieux aquatiques. ONEMA, 29 juin 2011 - http://www.onema.fr/dossier-secheresse-2011

[79] TYPSA (2013) Updated report on wastewater reuse in the European Union – Report for DG ENV

Water quality in France

Among the main water challenges facing the country, as stressed by the different River Basin Management Plans (RBMPs) developed in the context of the implementation of the WFD[80], diffuse nitrate and pesticide pollution (from agriculture in particular) and the ecological status of water bodies (in particular, issues concerning the hydromorphology of water bodies) are seen as particularly challenging.

Unlike the contamination of surface and ground water by several macro-pollutants, which has decreased in recent years, **pollution from nitrates** does not decrease at the national level. After a constant increase until 2004, nitrate concentrations in ground waters have remained stable –and high-, although significant regional differences exist. In surface waters, nitrate concentrations are more variable over the years, as they also depends on precipitations –in more rainy years, more nitrates are washed away from soils into rivers. Nitrates are one of the main causes of the bad ecological status of groundwater, according to the WFD definition. High nitrate concentrations degrade the resource so that additional measures are required to supply up-to-standards drinking water, like for example dilution with clean water, additional treatment or discarding especially polluted groundwater body as no longer viable drinking water sources. In surface water bodies, nitrate concentrations have decreased in the majority of cases in the period 1998-2011, although in some areas the opposite was recorded. In the case of **pesticides**, measured concentrations across the country are generally low, but widespread in all aquatic ecosystems. In 2011, pesticides were found in 93% of monitoring points on surface water bodies, and often different pesticides were reported in one monitoring station. 30% of monitoring points showed a concentration higher than 0.5 µg/l (annual average). This situation is unchanged since monitoring started in 1990. Groundwaters are characterised by a more significant presence of forbidden substances and by their degradation products. This more significant presence of forbidden substances can be explained by the inertia of groundwater bodies, which is a function of the groundwater body depth and the rocky formation lying below the water body: thus, even if pesticides sales have decreased in the country in recent years, and some substances were forbidden by law in 2003, the latter were still found in ground waters in 2011[81].

Water reuse potential

The current French regulation and its administrative burden is seen by water reuse producers and researchers as posing a strong barrier to a wider adoption of water reuse systems for irrigation. The Regulation is thought to be very strict, and difficult for operators to comply with in particular with regards to monitoring requirements and requirements for the pipeline network. The current regulation strictness is motivated by current scientific uncertainties on the actual risks associated to water reuse[82].

There are no recent data on the total volume of reused water in France, the latest data are from 2007: 19,200 m^3/day according to Jimenez et al. In 2015 there were about 40 reuse schemes in France, most of them are dedicated to irrigation (agriculture, public areas, golf courses and racecourses)[83].

Because of its good hydraulic infrastructure and sufficient rainfall around the country, France does not need to increase resources by relying heavily on water reuse. So far, most applications of wastewater reuse have been limited to peripheral small communities and islands mainly because of the cost of tertiary treatment. Nevertheless, the projects implemented cover more than 3,000 ha of land, and quite a wide variety of applications: market gardening crops, orchard fruit, cereals, tree plantations and forests, grasslands, gardens and golf courses[84].

The reuse of industrial wastewater after purification to supply cooling water, wash water or even process water after sophisticated complementary treatment is developing well in France. There are more than 10 projects in industrial wastewater treatment in France with examples in the automotive, textile, paper and food

[80] See for example the RBMP (SDAGE) of the Seine-Normandie River basin - http://www.eau-seine-normandie.fr/index.php?id=7959 .

[81] CGDD, 2014. *L'environnement en France – Edition 2014*. Commissariat Général au Développement Durable – Service de l'observation et des statistiques

[82] http://fr.slideshare.net/Voarino/la-reutilisation-des-eaux-usees-traitees ; http://www.ecoumenegolf.org/XEauXLAZAROVA.pdf

[83] BIO by Deloitte (2015) Optimising water reuse in the EU – Final report prepared for the European Commission (DG ENV), Part I. In collaboration with ICF and Cranfield University. http://ec.europa.eu/environment/water/blueprint/pdf/BIO_IA%20on%20water%20reuse_Final%20Part%20I.pdf

[84] TYPSA, 2013

industries of industrial wastewater. In some of these applications for the paper and food industry the treated water is reused. The applications also include rainwater catchment and reuse at a large automotive plant[85].

2.2 Wastewater collection and treatment

Overview of wastewater collection systems per sector

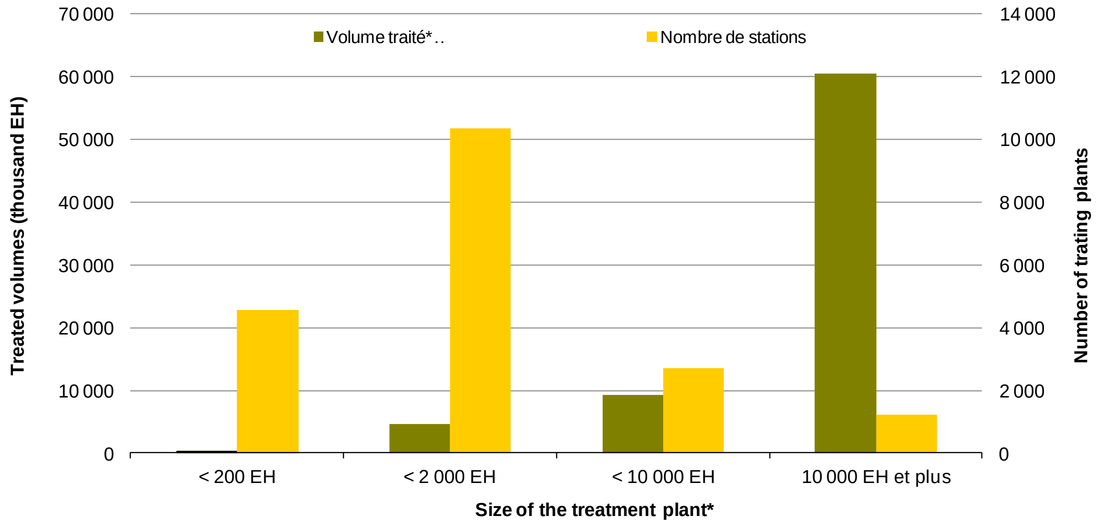
Domestic sector

The structure of the WSS sector in France is illustrated in section 2.1 of this document. The wastewater of 95% of the population was treated in 2004[86].

Industrial sector

Figure 2.6 presents yearly treated volumes (from 2008)[87]. In the graph, HE (French acronym) stands for Inhabitant Equivalent, which is a measurement unit based on the quantity of pollution emitted per person per day. According to the Wastewater Treatment Directive, the inhabitant equivalent is the organic charge which can be degraded through a five-day biochemical oxygen demand (BOD5) of 60 grams of oxygen per day.

Figure 2.6 Treated volumes and number of treating plant in 2008



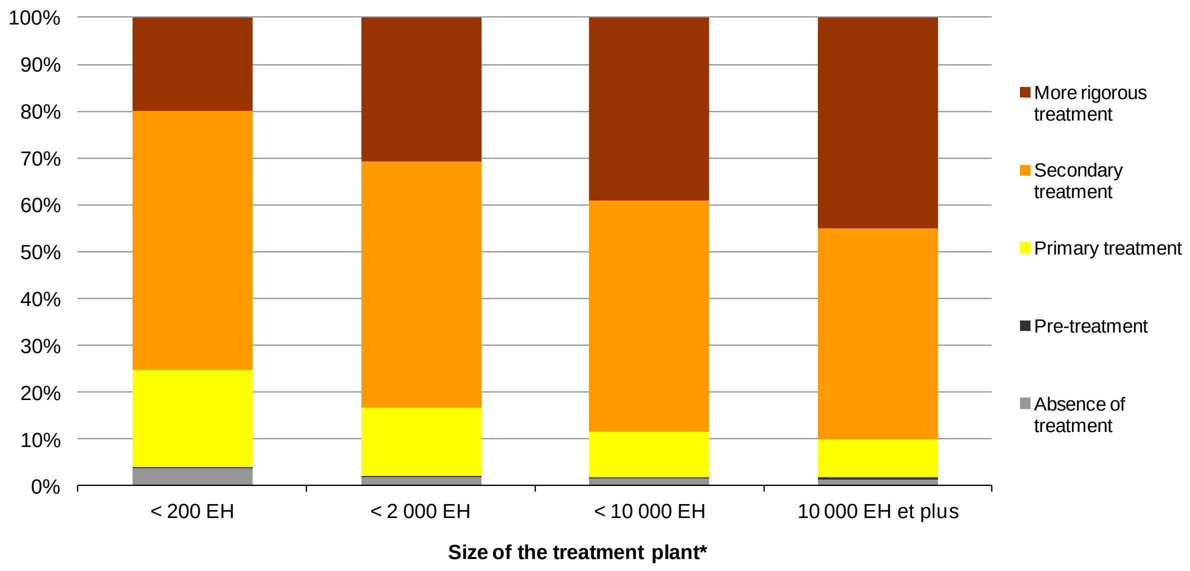
Source: http://www.statistiques.developpement-durable.gouv.fr/lessentiel/ar/306/1168/assainissement-traitement-collectif-eaux-usees.html

Treated effluent quality by volume and treatment level

Figure 2.7 presents the distribution of treatments plants by level of treatment and size in 2008.

[85] Angelakis et al. (2007) Wastewater recycling and reuse in EUREAU countries – Report for EUREAU
[86] P. 27 de IOWATer management france
[87] http://www.statistiques.developpement-durable.gouv.fr/lessentiel/ar/306/1168/assainissement-traitement-collectif-eaux-usees.html

Figure 2.7 Distribution of treatment levels per size of treatment plant in 2008



Source: http://www.statistiques.developpement-durable.gouv.fr/lessentiel/ar/306/1168/assainissement-traitement-collectif-eaux-usees.html

Wastewater treatment costs

Overall, in 2009 the total expenditure for wastewater collection and treatment amounted to €11.1 billion. More in detail:

- €1.9 billion were invested in treatment plants;
- €2.6 billion were invested in the sanitation network; and
- O&M costs amounted to €6.6 billion[88].

French legislative background for water reuse

In France, water reuse systems are already in place, and legally binding standards for reuse are in place. The existing standards concern water reuse for irrigation in agriculture and for the irrigation of green and recreational areas. France has adopted the approach based on limit values defined for a range of parameters of the water reused. The requirements for water reuse are strongly linked to the national legislation on the agricultural spreading of sewage sludge: not only the quality of the reuse water shall be monitored, but also the quality of the sewage sludge produced by the WWTP and the quality of the agricultural soils.

In total, 6 water quality parameters are fixed and compliance is checked against the limit values specified by the national legislation on agricultural spreading of sewage sludge[89].

Standards

The standards included in the French legislation are as follows:

Origin of the wastewater: Treated wastewater from urban WWTPs with a gross organic pollution greater than 1.2 kg of BOD5 per day.

Allowed uses: Food crops intended for human consumption, consumed raw; food crops intended for human consumption subject to thermal process; grassland; recreational areas (golf courses, forests open to public);

[88] http://www.planetoscope.com/eau-oceans/637-depenses-de-gestion-des-eaux-usees-en-france-en-euros-.html
[89] BIO by Deloitte, 2015

Flowers sold cut; Other flowers; Nursery and shrub; Fodder crops; Other cereal crops; Fruit production; Forest exploitation with limited public access.

Prohibited uses: Irrigation with raw sewage; Irrigation with treated wastewater from WWTPs connected to certain animal by-products processing installations; Irrigation with treated wastewater from WWTPs whose sewage sludge do not comply with limit values specified by the French legislation on agricultural use of sewage sludge; Irrigation with treated wastewater on soils that do not comply with limit values specified by the French legislation on agricultural use of sewage sludge; Irrigation with treated wastewater within the close protection perimeters of drinking water abstraction points (with some exceptions).

Approach: water quality levels are defined, each with specific numerical limit values for a range of parameters. The required quality level is specified for each use category. The particularity of the French approach is that the monitoring programme to be put in place partly relies on the monitoring of sewage sludge quality and agricultural soils, in accordance with the French legislation on the agricultural use of sewage sludge. Sewage sludge quality is indeed considered to be a reliable indicator of the overall WWTP efficiency with regard to the removal of pathogens and other hazardous substances.

Parameters: (i) parameters for the reclaimed water: suspended solids, chemical oxygen demand, faecal coliforms, F-specific bacteriophages, spores of sulphate-reducing anaerobic bacteria, E. coli; (ii) Specific parameters for sewage sludge and agricultural soils, in accordance with the French legislation on sewage sludge spreading[90].

Table 2.1 Water quality levels in French legislation[91]

Parameters	Sanitary quality levels of reused water			
	A	B	C	D
Suspended solids (mg/l)	15			
Chemical Oxygen Demand (mg/l)	60	In compliance with regulations of treated effluents released from the plant outside the irrigation season		
Faecal coliforms (abatement in log)	4	3	2	2
F-specific bacteriophages (abatement in log)	4	3	2	2
Spores of sulphate-reducing anaerobic bacteria (abatement in log)	4	3	2	2
E. coli (UFC/100 ml)	250	10 000	100 000	-

Table 2.2 Allowed uses by quality level [92]

Type of uses	Quality level			
	A	**B**	**C**	**D**
Fruit crops and vegetable crops non-transformed by a thermic industrial treatment (eaten raw)	+	-	-	-
Aquaculture, fruit crops and vegetable crops transformed by a thermic industrial treatment	+	+	-	-
Pastures	+	+	-	-
Green spaces and forests open to the public	+	-	-	-
Flowers sold cut	+	+	-	-
Other flowers	+	+	+	-
Nursery and shrubs	+	+	+	-
Other fodder and cereal crops	+	+	+	-
Fruit production	+	+	+	-
Forest exploitation with limited public access	+	+	+	+

+: allowed; -: forbidden

[90] BIO by Deloitte, 2015

[91] Arrêté du 2 août 2010 relatif à l'utilisation d'eaux issues du traitement d'épuration des eaux résiduaires urbaines pour l'irrigation de cultures ou d'espaces verts https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022753522&dateTexte=&categorieLien=id

[92] Arrêté du 2 août 2010 relatif à l'utilisation d'eaux issues du traitement d'épuration des eaux résiduaires urbaines pour l'irrigation de cultures ou d'espaces verts https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022753522&dateTexte=&categorieLien=id

Monitoring: Minimum required frequencies for the monitoring of the E. Coli parameter, for the different quality levels. The WWTP operator is in charge of implementing a monitoring programme (at the outlet of the WWTP) including: (i) Sampling and analysis of E. Coli according to a specific schedule; (ii) Annual monitoring of all 6 parameters; and (iii) Monitoring of the quality of sewage sludge produced by the WWTP (at least 4 times/year). The WWTP operator shall communicate the monitoring results to the Préfet, the mayors concerned and the users of irrigated land. If one parameter exceeds the limit value, the WWTP operator shall inform the users of irrigated plots, the Préfet and the municipalities concerned. At least every 10 years, the user of irrigated land shall perform an analysis of soil samples targeting the trace elements covered by the French legislation on the agricultural use of sewage sludge. Results shall be communicated to the WWTP operator. Traceability measures: irrigated plot managers have to maintain a register with indications of crop location and type, volumes of reused water, the time during which crops are irrigated with reused water and the results of the monitoring programme (on reclaimed water, sludge and soils)[93].

Table 2.3 Frequency of monitoring per quality level [94]

Use requiring a minimum level of:	Frequency of monitoring	E. coli – Limit value to be respected (UFC/100 ml)
A	1 per week	250
B	1 every 15 days	10 000
C & D	1 per month	100 000

Application controls: (i) Several measures required to avoid cross contamination risks between the reclaimed water network and the drinking water network; (ii) Setback distances between areas irrigated with treated wastewater and specific activities; (iii) Maximum authorised land slope; (iv) Spray irrigation cannot be conducted if wind speed exceeds specified values.

Permitting system: An authorisation shall be granted by the Préfet (local competent authority) before reusing treated wastewater. It can be submitted by the WWTP operator or the owner of irrigated land. The contents of the application file are specified by the regulation[95].

Depending on the parameter, quality measurements can be over the limit for a certain number of days per year (the number of days is fixed for each parameter, depending on the requested monitoring frequency).

Measurement frequencies are presented in the figures below.

[93] BIO by Deloitte, 2015
[94] Arrêté du 2 août 2010 relatif à l'utilisation d'eaux issues du traitement d'épuration des eaux résiduaires urbaines pour l'irrigation de cultures ou d'espaces verts https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022753522&dateTexte=&categorieLien=id
[95] BIO by Deloitte, 2015

Figure 2.8 Minimal measurement frequency (number of day per year) per parameter[96]

CAS	Paramètres	CODE SANDRE		CAPACITÉ NOMINALE DE TRAITEMENT DE LA STATION EN KG/J DE DBO5						
		Paramètre	Unité	≥ 120 et < 600	≥ 600 et < 1800	≥ 1 800 et < 3 000	≥ 3 000 et < 6 000	≥ 6 000 et < 12 000	≥ 12 000 et < 18 000	≥ 18 000
Cas général en entrée et en sortie	Débit	1552	120	365	365	365	365	365	365	365
	pH	1302	264	12	24	52	104	156	365	365
	MES	1305	162	12	24	52	104	156	260	365
	DBO5	1313	175	12	12	24	52	104	156	365
	DCO	1314	175	12	24	52	104	156	260	365
	NTK	1319	168	4	12	12	24	52	104	208
	NH4	1335	169	4	12	12	24	52	104	208
	NO2	1339	171	4	12	12	24	52	104	208
	NO3	1340	173	4	12	12	24	52	104	208
	Ptot	1350	177	4	12	12	24	52	104	208
Cas général en sortie	Température	1301	27	12	24	52	104	156	365	365
Zones sensibles à l'eutrophisation (paramètre azote) en entrée et en sortie (2)	NTK	1319	168	4	12	24	52	104	208	365
	NH4	1335	168	4	12	24	52	104	208	365
	NO2	1339	168	4	12	24	52	104	208	365
	NO3	1340	168	4	12	24	52	104	208	365
Zones sensibles à l'eutrophisation (paramètre phosphore total) en entrée et en sortie		1350	177	4	12	24	52	104	208	365

(1) Dans le cas où la charge brute de pollution organique reçue par la station l'année N est supérieure à la capacité de la station, les fréquences minimales de mesures et les paramètres à mesurer l'année N + 2 sont déterminés à partir de la charge brute de pollution organique.
(2) Sauf cas particulier, les mesures en entrée des différentes formes de l'azote peuvent être assimilées à la mesure de NTK.

Figure 2.9 Minimal treatment performance expected for the parameters: BOD5, COD, SEM[97]

PARAMÈTRE	CHARGE BRUTE de pollution organique reçue par la station en kg/j de DBO5	CONCENTRATION maximale à respecter, moyenne journalière	RENDEMENT MINIMUM à atteindre, moyenne journalière	CONCENTRATION rédhibitoire, moyenne journalière
DBO5	< 120 ≥ 120	35 mg (O2)/l 25 mg (O2)/l	60 % 80 %	70 mg (O2)/l 50 mg (O2)/l
DCO	< 120 ≥ 120	200 mg (O2)/l 125 mg (O2)/l	60 % 75 %	400 mg (O2)/l 250 mg (O2)/l
MES (*)	< 120 ≥ 120	/ 35 mg/l	50 % 90 %	85 mg/l 85 mg/l

Le respect du niveau de rejet pour le paramètre MES est facultatif dans le jugement de la conformité en performance.
(*) Les valeurs des différents tableaux se réfèrent aux méthodes normalisées, sur échantillon homogénéisé, non filtré ni décanté. Toutefois, les analyses effectuées en sortie des installations de lagunage sont effectuées sur des échantillons filtrés, sauf pour l'analyse des MES. La concentration rédhibitoire des MES dans les échantillons d'eau non filtrée est alors de 150 mg/l en moyenne journalière, quelle que soit la CBPO traitée.

Figure 2.10 Minimum treatment performance expected for the parameters N and P, in case the treatment plant discharges its effluents in areas subject to eutrophication [98]

REJET EN ZONE SENSIBLE à l'eutrophisation	PARAMÈTRE	CHARGE BRUTE de pollution organique reçue par la station en kg/j de DBO5	CONCENTRATION maximale à respecter, moyenne annuelle	RENDEMENT MINIMUM à atteindre, moyenne annuelle
Azote	NGL (1)	> 600 et ≤ 6000 > 6 000	15 mg/l 10 mg/l	70 % 70 %
Phosphore	Ptot	> 600 et ≤ 6 000 > 6 000	2 mg/l 1 mg/l	80 % 80 %

(1) Les échantillons utilisés pour le calcul de la moyenne annuelle sont prélevés lorsque la température de l'effluent dans le réacteur biologique est supérieure à 12 °C.

[96] Arrêté du 21 juillet 2015 relatif aux systèmes d'assainissement collectif et aux installations d'assainissement non collectif, à l'exception des installations d'assainissement non collectif recevant une charge brute de pollution organique inférieure ou égale à 1,2 kg/j de DBO5

[97] Arrêté du 21 juillet 2015 relatif aux systèmes d'assainissement collectif et aux installations d'assainissement non collectif, à l'exception des installations d'assainissement non collectif recevant une charge brute de pollution organique inférieure ou égale à 1,2 kg/j de DBO5

[98] Arrêté du 21 juillet 2015 relatif aux systèmes d'assainissement collectif et aux installations d'assainissement non collectif, à l'exception des installations d'assainissement non collectif recevant une charge brute de pollution organique inférieure ou égale à 1,2 kg/j de DBO5

2.3 Agricultural irrigation: baseline

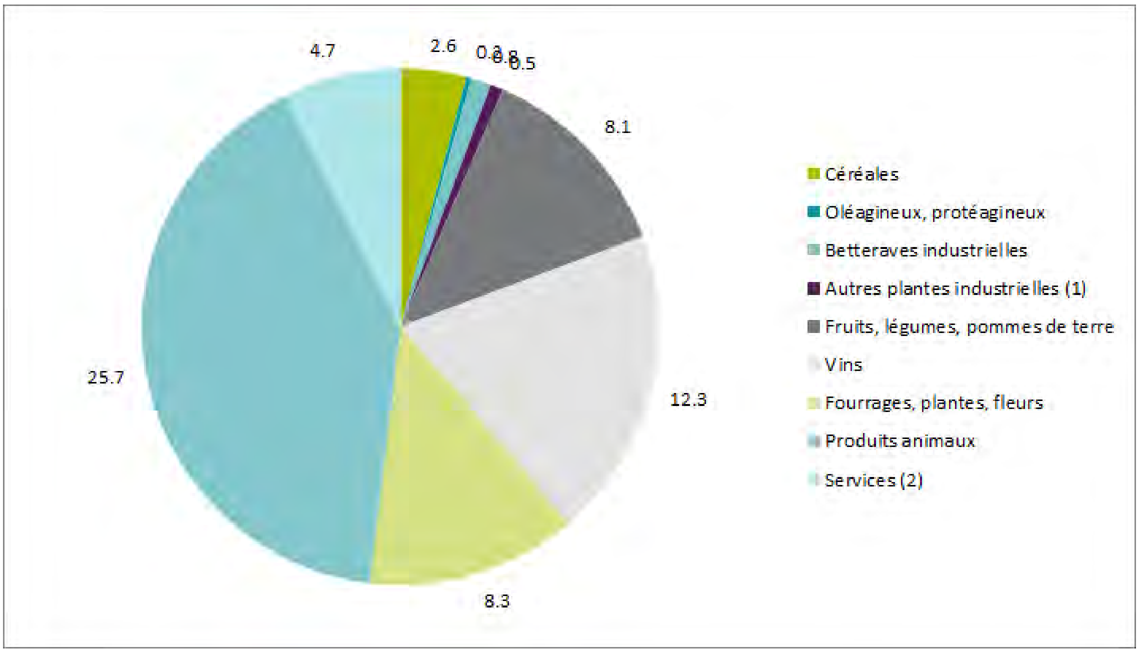
Agricultural sector profile

Land use according to Lucas classification in 2009 showed the following picture for France:

- 54.2% agriculture;
- 21.7% forestry;
- 1.1% Hunting & Fishing;
- 3.7% Heavy Environmental Impact;
- 9.3% Services & Residential Use; and
- 10% No visible use.

The agricultural sector accounts for nearly 2% of the total gross value added of the French economy in 2013 (Eurostat data). Figure 2.6 shows the contribution by type of crop/activity to the total gross value added of the agricultural sector[99].

Figure 2.11 Contribution to gross value added by type of products in 2010

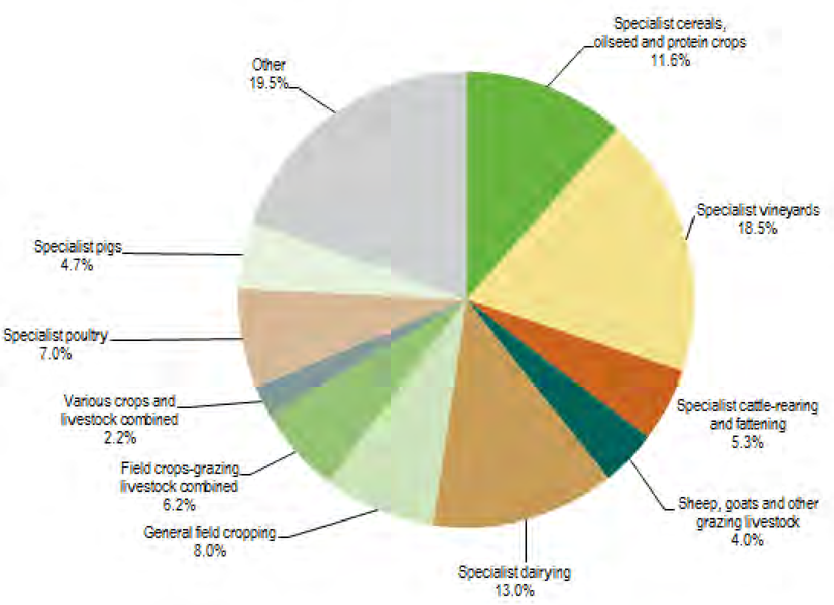


Source : Insee, comptes prévisionnels de l'agriculture - base 2010

The standard output of agriculture (in €) by type of crop is provided in Figure 2.12.[100]

[99] http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_census_in_France
[100] http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_census_in_France

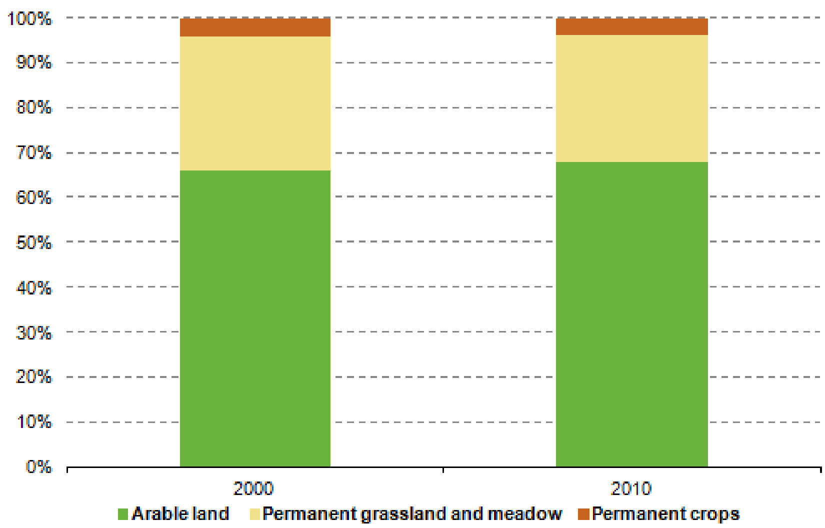
Figure 2.12 Overview of value of agriculture outputs by type of crops in 2010



Source : http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_census_in_France

Agricultural land use has remained stable in France between 2000 and 2010 as illustrated in Figure 2.8.[101]

Figure 2.13 Overview of evolution of land use in France between 2000 and 2010



Agricultural irrigation

Overall, in 2009 agriculture accounted for 26% of the total water abstracted by the domestic, agricultural and industrial sectors, and 9% of the total water abstracted in France (thus including hydropower production)[102].

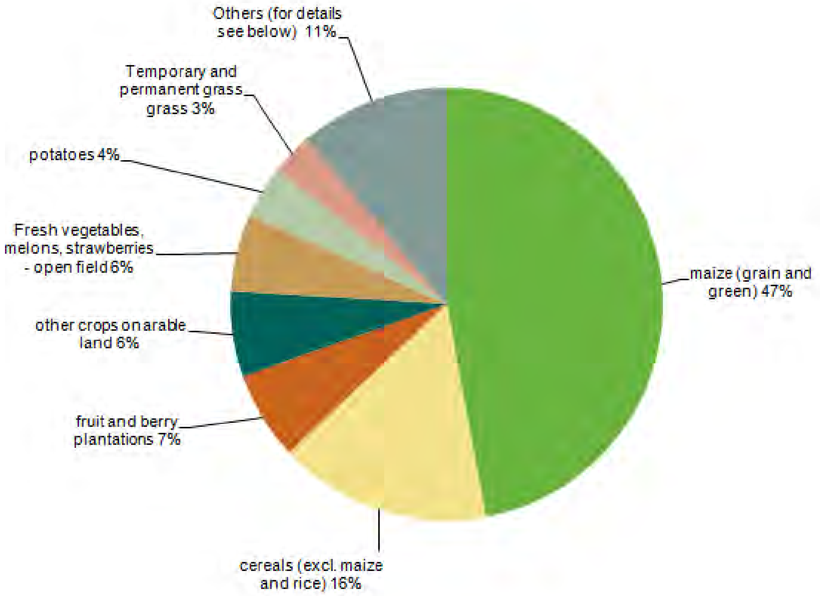
Despite the importance of this sector it provides less than 3% of employment in France in terms of direct jobs.

[101] http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_census_in_France

[102] CGDD, 2012

In 2010, the total agricultural area equipped for irrigation amounts to 27.7 million hectares; however, it was reported that irrigation actually occurred on 1.6 million hectares, corresponding to a total water use of 2.7 billion m³. The irrigated area by type of crop is illustrated in Figure 2.9[103].

Figure 2.14 Irrigated area by type of crop in 2010



Source: http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_census_in_France

In France, both volumetric and mixed tariffs are applied to the provision of irrigation water, mixed tariffs being the most common. The EEA (2013) reports flat tariffs ranging between 38 and 157 EUR/year, combined with volumetric rates ranging between 0.06 and 0.09 EUR/m³. Tariffs paid by farmers cover 100% of operation and maintenance costs, but they do not fully cover investment costs: depending on the area, revenues from tariffs cover from 15% to 95% of investments costs (55% on average)[104].

In addition to the tariff for the services, farmers pay also abstraction charges to water agencies. But these are very low and significantly lower than abstraction charg rates for other water users (on average 0.001 to 0.003€/m³ (- EEA, 2013)). Although differences in water charge rates exist between catchment under water deficit and other catchments, these rates remain very low in both cases and do not provide any incentive to save water. As part of the 10th program (2013-2018) of water agencies, farmers contribution to abstraction fees has globally increased, but not in all river basins. For instance in the Seine-Normandy river basin, fees for irrigation remain stable (2% of the total abstraction fees) while irrigation remain the main responsible for water abstraction[105]. The choices made by basin committees on fees level are linked to social, climate and economical aspects.

The reuse of water for irrigation purposes is still little developed in France. Water reuse for irrigation is limited to particular regions, such as islands or areas with a high water demand and uses possibly conflicting with potable use (e.g. tourism). Furthermore, the price of reused water is higher than the price of conventional water, so there is little economic incentive to switch to reused water. Figure 2.10 illustrates the average daily volume of recycled water used for irrigation in different countries and shows that out of the group presented below France is the country with the lowest daily use[106].

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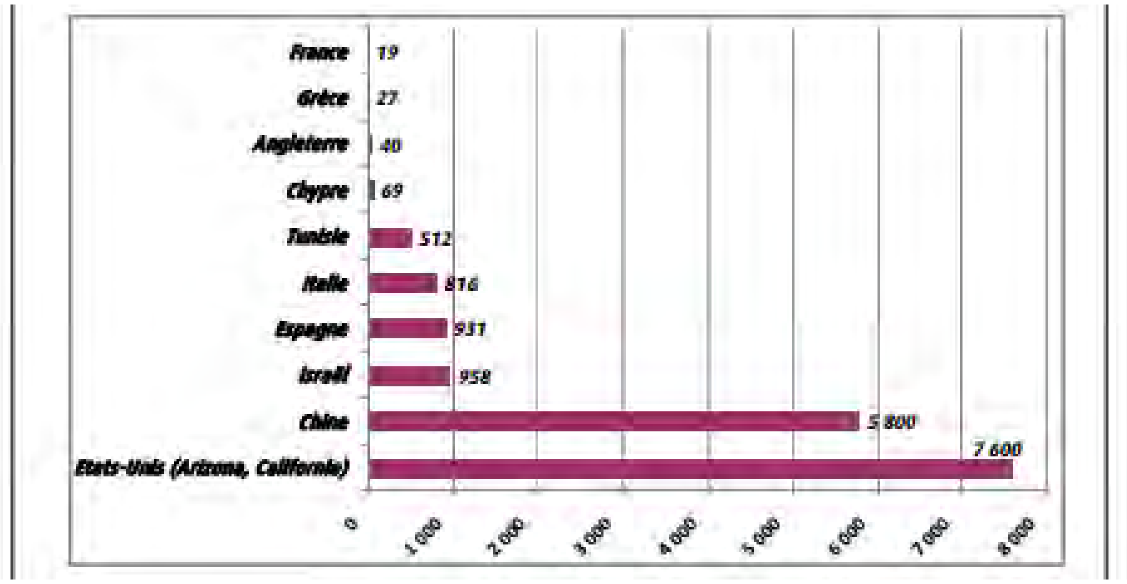
[103] http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_census_in_France

[104] EEA, 2013. Assessment of cost recovery through pricing of water. Technical report No 16/2013. http://www.eea.europa.eu/publications/assessment-of-full-cost-recovery

[105] http://www.lesagencesdeleau.fr/wp-content/uploads/2012/11/10emepg_SN.pdf

[106] http://www.developpement-durable.gouv.fr/IMG/pdf/LPS191.pdf

Figure 2.15 Average daily volume of recycled water used for irrigation in 2007

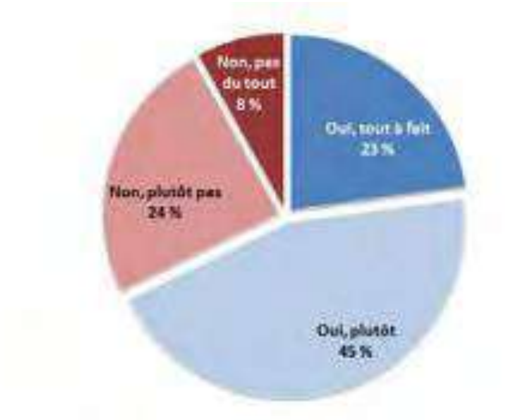


Source: http://www.developpement-durable.gouv.fr/IMG/pdf/LPS191.pdf

At the end of the 90s, only around 20 water reuse projects could be found in France; all projects were set up for irrigation of crops, green spaces and golf courses. The largest water recycling project provides irrigation water to 2300 ha (data published in 2007). More updated data are not available, although it seems that little additional projects have been set up since then[107].

While French population already eats fruits and vegetables imported from countries where water reuse for irrigation is frequent (e.g. Spain), a third declared not to be ready to eat fruits and vegetables irrigated with recycled water (see Figure 2.11). This suggests that consumers have little awareness of the practices occurring abroad.[108]

Figure 2.16 Consumers acceptability of consumption of vegetables and fruits irrigated with water reuse



Source: CGDD, May 2014

2.4 Agricultural irrigation: proposal

General overview: comparison of the draft JRC quality standards and standards applied in France

[107] http://www.ecoumenegolf.org/XEauXLAZAROVA.pdf
[108] http://www.developpement-durable.gouv.fr/IMG/pdf/LPS191.pdf

Allowed uses

As shown in the table below, both the French and draft JRC proposal establish four quality categories, intended for different types of uses. The types of uses allowed for each category in the French regulation largely corresponds to the provisions of the draft JRC proposal.

Quality category	Allowed uses - France	Allowed uses - draft JRC proposal
A	Fruits and vegetables to be eaten raw; all other uses	Food crops to be eaten raw
B	Fruits and vegetables transformed by a thermic industrial treatment, pastures, flowers, nursery and shrubs, fodder and cereal crops, fruit production, forest exploitation with limited public access	Processed food crops to be eaten after a treatment process
C	Flowers not to be sold cut, nursery and shrubs, fodder and cereal crops, fruit production, forest exploitation with limited public access	Crops which are not intended for human consumption (e.g. pastures, forage, fibre, ornamental, seed, forest, and turf crops)
D	Forest exploitation with limited public access	

Quality parameters

The two tables below show the quality parameters according to the French regulation and the draft JRC proposal. The following considerations can be made:

- Total suspended solids is a parameter considered in both regulations. However, in the French regulation this parameter is considered only for the quality category A, and the limit is 15 mg/l against 10 mg/l included in the draft JRC proposal. The draft JRC proposal includes thresholds for all other categories, which are not included in the French regulation;
- Escherichia coli is a parameter considered in both regulations for quality categories A, B and C. However, the maximum allowed thresholds set by the draft JRC proposal are more restrictive than the thresholds set by the French regulation;
- The French regulation does not include turbidity, which is considered by the draft JRC proposal;
- Levels of organic substances: the French regulation include COD thresholds for the quality categories A and B, the draft JRC proposal include BOD thresholds for all quality categories. COD levels are normally higher than BOD thresholds, but still it seems that the draft JRC proposal for category A are more restrictive than the French requirements;
- Bacteriological parameters are included in the French regulation, but not in the draft JRC proposal ; and
- Turbidity is included in the draft JRC proposal, but not in the French regulation.

Table 2.4 Overview of water quality in French legislation

France - Parameters	Sanitary quality levels of reused water			
	A	B	C	D
Total suspended solids (mg/l)	15			
Chemical Oxygen Demand (mg/l)	60	In compliance with regulations of treated effluents released from the plant outside the irrigation season		
Faecal coliforms (abatement in log)	4	3	2	2
F-specific bacteriophages (abatement in log)	4	3	2	2
Spores of sulphate-reducing anaerobic bacteria (abatement in log)	4	3	2	2
E. coli (UFC/100 ml)	250	10 000	100 000	-

Table 2.5 Overview of water quality in draft JRC proposal

Draft JRC proposal - Reclaimed water quality category	E. coli (CFU/100 ml)		Total Suspended Solids (TSS) (mg/l)		Biochemical Oxygen Demand (BOD5) (mg/l)		Turbidity (NTU)	
	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
A: Very High quality	≤10	100	≤5	10	≤5	10	≤2	5
B: High quality	≤200	1,000	≤10	25	≤10	20	-	-
C: Good quality	≤1,000	10,000	≤35	35	≤25	25	-	-
D: Medium quality	-	-	≤35	35	≤25	25	-	-

<u>Monitoring</u>

The draft JRC proposal only establishes that all quality parameters should be monitored. In the French regulation, all quality parameters should be monitored with a given frequency (frequency depends on the parameter). It is therefore not possible to make a comparison between these two regulations, as the draft JRC proposal is not developed enough on this aspect yet.

<u>General comparison</u>

Overall, it seems that the draft JRC proposal **is more restrictive than the existing French regulation**. On bacteriological parameters, however, the French regulation poses restrictions which are not included in the draft JRC proposal. Nevertheless, both regulations are based on the same quality categories, which means that the French regulation could be easily adjusted to the draft JRC proposal.

Non-binding standards for water reuse

As France has already articulated, legislation on water reuse for irrigation purposes, it is almost impossible to ascertain whether non-binding EU standards for water reuse would have any effect in the country. If EU standards are not binding, a Member State such as France, might as well decide to keep its own standards in place, to avoid: (i) administrative burden; and (ii) additional compliance costs for water reuse companies. On the other hand, adherence to EU non-binding standards might be seen as a further safety guarantee by water users. For example consumers might then be more willing to buy fruit and vegetables to be eaten raw irrigated with recycled water.

For the IA exercise, and in order to differentiate this policy option from the baseline scenario, the following scenario can be assumed: France will not change the parameters to be monitored. However, on the common parameters shared with the draft JRC proposal (TSS, E. Coli), the allowed thresholds will be adjusted to the proposed JRC thresholds; for COD, existing thresholds will be lowered to be equivalent to the BOD thresholds set by the draft JRC proposal. This hypothesis will be the basis for the Impact Assessment.

Legally binding standards for water reuse

Under this scenario, France would adjust its existing standards to the draft JRC proposal. In short, this will imply: (i) lowering the thresholds for E. Coli and TSS; (ii) introducing BOD among the parameters (possibly in substitution of the COD parameter); and (iii) introducing the turbidity parameter. It is impossible to infer whether microbial parameters, currently included in the French regulation, will be kept as quality standards. For the purpose of the IA exercise, it can be assumed that these standards will still be included in the French regulation (as they are today).

2.5 Agricultural irrigation: impact assessment

The assessment of impacts for both options is presented in the table below.

Economic impacts	Non-binding standards for water reuse	Binding standards for water reuse
Functioning of the internal market and competition	No relevant impacts are expected	No relevant impacts are expected –as the regulations would equally apply to all water reclamation operators.
Operating costs and conduct of business/Small and Medium Enterprises	Existing reclamation plants might need to upgrade their treatment units to comply with lower thresholds of quality parameters (TSS, E. Coli and COD), and this would imply additional costs. However, it is not possible to estimate a magnitude of these costs –it will depend on technologies currently in use. The current French regulation is seen as posing a strong barrier to a wider adoption of water reuse systems for irrigation because it is too strict, and it is difficult for operators to comply with monitoring requirements and the requirements for the pipeline network[109]. This policy option includes stricter limits on some parameters, and it is assumed that other requirements will not change (e.g. monitoring protocols, requirements for pipelines, etc.). Therefore, it can be assumed that this policy option might be even (slightly) more constraining for the development of the water reuse sector for irrigation purposes in France.	Existing reclamation plants might need to upgrade their treatment units to comply with lower thresholds of quality parameters (TSS, E. Coli), as well as additional quality standards (turbidity, BOD); this would imply additional costs. However, it is not possible to estimate a magnitude of these costs –it will depend on technologies currently in use. These costs might be higher as compared to the non-binding option. The current French regulation is seen by some authors as posing a strong barrier to a wider adoption of water reuse systems for irrigation. In the draft JRC proposal whether monitoring requirements (especially frequency) and requirements for the pipeline network will be stricter or easier to be attained by water operators. Therefore, it is not possible to infer whether the draft JRC proposal will be more or less constraining for water reuse operators.
Administrative burdens on businesses	Higher quality standards on the three parameters might require that existing water reclamation plant submit an application for adjusting their permit to the new regulation (water reuse must be permitted through an Arrêté préfectoral). This might imply additional administrative costs for water reclamation companies. However, this is just a hypothesis. No additional monitoring costs are expected, as the same parameters will need to be monitored, and with the same frequency –as compared to the current situation.	Higher quality standards, as well as additional standards might require that existing water reclamation plant submit an application for adjusting their permit to the new regulation (water reuse must be permitted through an Arrêté préfectoral). This might imply additional administrative costs for water reclamation companies. However, this is just a hypothesis. Additional monitoring costs can be expected, as additional parameters need to be monitored. In addition, measuring BOD levels is much more time-consuming than measuring COD levels, and this also implies additional costs.
Public authorities	No significant impact is expected on budgets of public authorities. As mentioned above, stricter limits on some parameters might require water reclamation companies to submit an application to adjust their current permits, and this might involve some administrative costs for public authorities in charge of issuing permits. However, at present very little water reclamation plant exist in the country, so the overall impact would not be significant. In addition, the current overall threshold system (quality categories, quality parameters) would not change as compared to the current situation, so upgrading the limits on some parameters would not require significant administrative adjustments.	No significant impact is expected on budgets of public authorities. As mentioned above, stricter limits on some parameters might require water reclamation companies to submit an application to adjust their current permits, and this might involve some administrative costs for public authorities in charge of issuing permits. However, at present very little water reclamation plant exist in the country, so the overall impact would not be significant. In addition, the draft JRC proposal establishes the same quality categories established by the French system, and the two regulations have some quality parameters in common. Thus, upgrading the regulation should not imply a significant administrative burden.
Innovation and research	The introduction of stricter limits for some quality parameters might promote research on innovative treatment technologies.	The introduction of stricter limits for some quality parameters might promote research on innovative treatment technologies.
Consumers and households	Additional costs for water reclamation plants might imply increased costs for water users. Additional costs might be charged on farmers: however, an increase in irrigation water price might provide a negative incentive to the use of recycled water in irrigation. Alternatively, as it often happens, additional costs might recovered through cross-subsidization mechanisms, i.e.	Additional costs for water reclamation plants might imply increased costs for water users. Additional costs might be charged on farmers: however, an increase in irrigation water price might provide a negative incentive to the use of recycled water in irrigation. Alternatively, as it often happens, additional costs might recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low,

[109] http://fr.slideshare.net/Voarino/la-reutilisation-des-eaux-usees-traitees ; http://www.ecoumenegolf.org/XEauXLAZAROVA.pdf

Economic impacts		
	prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with available data and information. On the other hand, stricter quality limits might increase consumer protection.	to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with available data and information. On the other hand, adjusting national standards to EU standards might have a positive impact on the public perception of using recycled water for irrigation, as it might serve as a further guarantee of the overall safety of the system. Stricter quality limits and additional parameter to be monitored might increase consumer protection.

Social impacts	Non-binding standards for water reuse	Binding standards for water reuse
Employment and labour markets	In case the policy option will promote research on innovative technologies, some jobs might be created. It is not possible to quantify this impact –however, it is not expected to be significant, especially considering that this policy option is not expected to promote a wider adoption of water recycling for irrigation.	In case the policy option will promote research on innovative technologies, some jobs might be created. It is not possible to quantify this impact, especially because, at this stage, it is not possible to infer whether the draft JRC proposal will promote or further constrain the development of water recycling for irrigation purposes.
Governance, participation, good administration, access to justice, media and ethics	Stricter quality limits might increase consumer protection.	Adjusting national standards to the draft JRC proposal might have a positive impact on the public perception of using recycled water for irrigation, as it might serve as a further guarantee of the overall safety of the system. Stricter quality limits and additional parameter to be monitored might increase consumer protection.
Public health and safety	The current French regulation is considered to be very restrictive, and this is motivated by current uncertainties on the actual health impact of water recycling for irrigation. Therefore, it can be expected that the current national legislation is already protecting the population against the possible risks. Nevertheless, this policy option proposes even stricter quality standards for recycled water, so it is expected to increase the level of health protection of these practices.	The current French regulation is considered to be very restrictive, and this is motivated by current uncertainties on the actual health impact of water recycling for irrigation. Therefore, it can be expected that the current national legislation is already protecting the population against the possible risks. Nevertheless, the draft JRC proposal establishes even stricter quality standards for recycled water, so it is expected to increase the level of health protection of these practices.

Environmental impacts	Non-binding standards for water reuse	Binding standards for water reuse
Water quality and resources	Overall, water recycling decrease quantitative pressures on freshwater resources, by giving “a second life” to water. However, it does not seem that this policy option will promote an expansion of water recycling practices in the country, so no significant changes on current qualitative pressures on freshwater resources can be expected.	Overall, water recycling decrease quantitative pressures on freshwater resources, by giving “a second life” to water. At this stage, it is unclear whether the draft JRC proposal will further constrain or promote water reuse practices in the country, so it is not possible to infer whether quantitative pressures on freshwater resources will decrease.
Renewable or non renewable resources	No significant impacts are expected.	No significant impacts are expected.
The environmental consequences of firms and consumers	Irrigating crops with recycled water is in principle an environmental-friendly practice, as it spares freshwater resources which can be diverted to other uses (e.g. domestic) or to the environment. However, it does not seem that this policy option will promote an expansion of water recycling practices in the country, so no significant impact is expected on current levels of agricultural production with recycled water.	Irrigating crops with recycled water is in principle an environmental-friendly practice, as it spares freshwater resources which can be diverted to other uses (e.g. domestic) or to the environment. At this stage, it is unclear whether the draft JRC proposal will further constrain or promote water reuse practices in the country, so it is not possible to figure out the potential impact on current levels of agricultural production with recycled water.

2.6 Agricultural irrigation: Comparison of the alternative policy options

- Economic impacts:
  - Both policy options might imply additional costs for water reuse operators; the costs of option 2 (binding standards) might be higher than the costs of option 1 (non-binding standards);

- The current French regulation is seen as very restrictive, and as posing barriers to the expansion of water reuse practices for irrigation purposes in the Country. Option 1 poses stricter limits on some quality parameters, whereas current monitoring and pipeline requirements will be unchanged, so it might be even (slightly) more constraining for the water reuse sector. In the case of option 2, quality standards will be stricter, but it is unclear at this stage whether monitoring and pipeline requirements will be more or less strict; it is thus not possible to infer whether this option will promote or constrain water reuse for irrigation in the country;
- No additional monitoring costs for water reuse operators are expected in option 1. Some additional monitoring costs can be expected in option 2;
- The current French system and the draft JRC proposal have several common points (quality categories for different uses, some quality parameters), so upgrading the national regulation should not imply a significant administrative burden –although some additional administrative costs might be incurred by public authorities for the upgrade of current permits;
- Additional costs for water reuse operators might results in additional costs for water users in both options, and this can concern either farmers or other water users through cross-subsidization mechanisms. However, it is impossible at the moment to assess the possible magnitude of this impact; and
- In the case of option 2, adjusting national standards to the draft JRC standards might have a positive impact on the public perception of using recycled water for irrigation, as it might serve as a further guarantee of the overall safety of the system. In both Option 1 and 2, stricter quality limits and additional parameter to be monitored might increase consumer protection.

- Social impacts:
  - Both options are expected to increase the level of health protection of water reuse practices.
- Environmental impacts:
  - It does not seem that option 1 will promote an expansion of water recycling practices in the country, so no significant changes on current qualitative pressures on freshwater resources can be expected; and
  - At this stage, it is unclear whether option 2 (binding standards) will further constrain or promote water reuse practices in the country, so it is not possible to infer whether quantitative pressures on freshwater resources will decrease.

Table 2.6 Synthesis table of impact assessment for agriculture irrigation

	Non-binding standards for water reuse	**Binding standards for water reuse**
Overall economic impact	**0/-**	**0/-**
Functioning of the internal market and competition	0	0
Operating costs and conduct of business/Small and Medium Enterprises	- -	-
Administrative burdens on businesses	-	- -
Public authorities	0	0
Innovation and research	+	+
Consumers and households	-	-
Overall social impact	**0/+**	**+**

Employment and labour markets	0	0
Governance, participation, good administration, access to justice, media and ethics	0/+	+
Public health and safety	+	++
Overall environmental impact	**0**	**0/+**
Water quality and resources	0	0/+
Renewable or non-renewable resources	0	0
The environmental consequences of firms and consumers	0	0/+

++ Significant positive impact	**- -** Significant negative impact	**0** No relevant impact
+ Mild positive impact	**-** Mild negative impact	

2.7 Aquifer recharge: baseline

Groundwater resources

The volume of groundwater in France is estimated at 2,000 billion m^3, of which 100 billion m^3 per year flow through springs and water courses. About 7 billion m^3 per year are extracted from groundwater through the exploitation of springs, wells and drillings. Half of the water is used for drinking water[110], covering two thirds of the demand of drinking water[111,112].

Out of the 646 groundwater bodies in France, 90.6% were in a good quantitative status in 2013. Water bodies with less than good status are mainly situated in the South-East and the centre, the Mediterranean region as well as the islands Réunion and Mayotte. The main reasons for not reaching good status are overexploitation of the aquifers compared to their recharge, but also salt water intrusion (Réunion and Mediterranean region). Regarding groundwater quality, 67% of the groundwater bodies were in good chemical status in 2013[113].

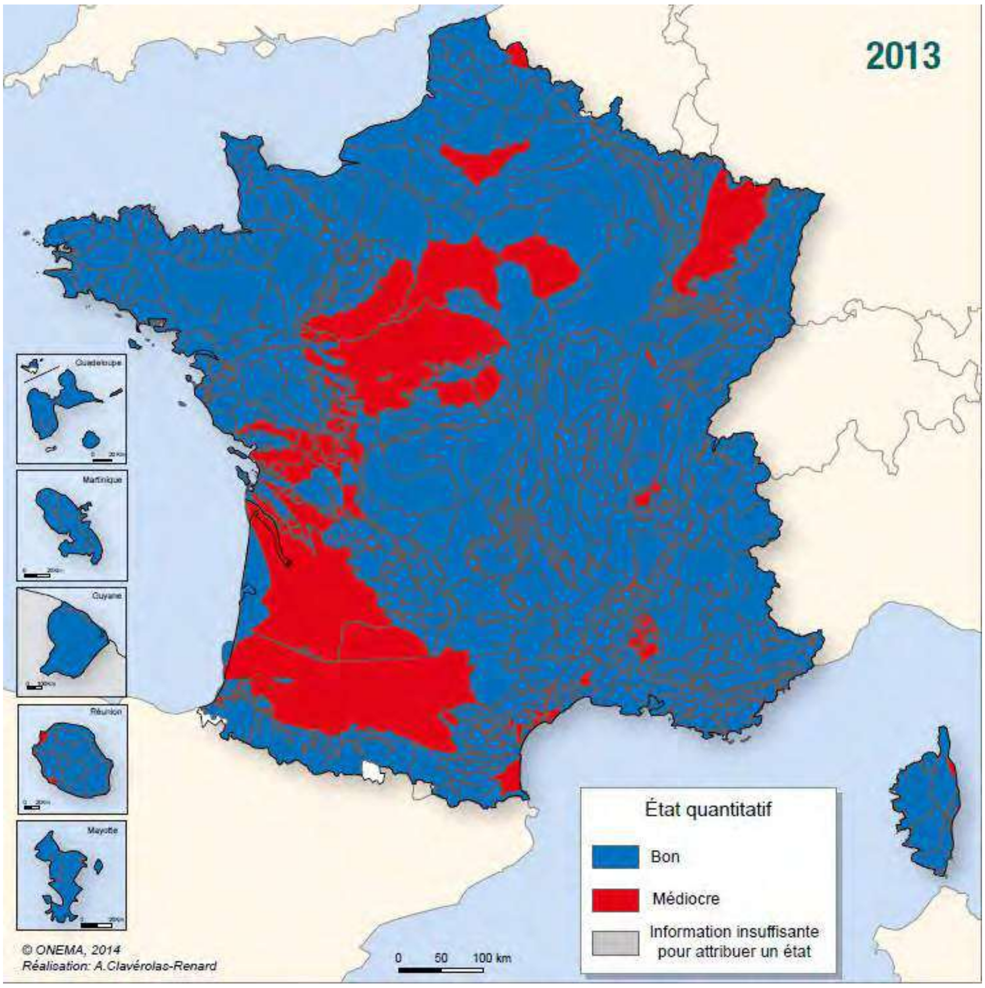
[110] http://www.eaufrance.fr/comprendre/les-milieux-aquatiques/eaux-souterraines

[111] BRGM (2016) Recharge des nappes et adaptation au changement climatique. Dossier de presse. 20 April 2016. http://www.brgm.fr/sites/default/brgm/publications/dp_2016-04_nappes/files/assets/common/downloads/dp_2016-04_nappes.pdf

[112] The reference year of the data is not provided by the original source. The same numbers are provided by other sources too, but the reference year is not indicated either.

[113] Eaufrance (2015) L'état des eaux de surface et des eaux souterraines. Les Synthèses, N°12, Juin 2015. http://www.eaufrance.fr/IMG/pdf/evaluation_2010-2013_201506.pdf

Figure 2.17 Quantitative status of groundwater bodies in France 2013 (Blue: good quantitative status; Red: not good)



Source: ONEMA, 2014 in: eaufrance, 2015

Aquifer recharge

Relevant legislative background

The following **French regulations** and aspects are relevant in the context of artificial groundwater recharge[114]:

- Artificial recharge of groundwater is subject to the regulation on installations, works and activities which requires an **authorisation** or a declaration in application of the articles L.214-1 to L.214-6 of the Code of the Environment. The prior authorisation for artificial groundwater recharge is hence mandatory. This forms also part of the basic measures under the WFD;
- Artificial groundwater recharge is also concerned by other texts transposing the **WFD** and its daughter **Directive on groundwater**. This includes in particular the **decree from 17 July 2009** (the transposition of article 6 of the daughter directive on groundwater (2006/118)), concerning the **prevention and limitation of introductions of pollutants in groundwater**. The environmental objective of preventing and limiting the introduction of pollutants in groundwater has been transposed into French law in point IV.4 of article L.212-1 of the Code of the Environment and the article R212-9-1 of the Code of the Environment. However, the provisions of article R.212-9-1 of the Code of the Environment which prohibit the direct or indirect

[114] Casanova, J., Cagnimel, M., Devau, N., Pettenati, M., and Stollsteiner, P. (2013) Recharge artificielle des eaux souterraines : état de l'art et perspectives. BRGM & ONEMA. http://www.onema.fr/IMG/pdf/2013_044.pdf

introduction of dangerous substances or which limit the direct or indirect introduction of non-dangerous pollutants in groundwater don't apply to the introduction of dangerous substances or non-dangerous pollutants which result from the artificial recharge of groundwater (article 10.2 of the decree from 17th of July 2009). This exception is possible only after the setting up of a monitoring control of the groundwater bodies concerned or another appropriate control;

- The WFD also states that the water used for artificial recharge can come from any surface or groundwater source, under the condition that the use of the source does **not compromise reaching the environmental objectives** fixed for the water source or the recharged groundwater body. In France, in the absence of a ministerial decree with general prescriptions regarding this issue, this constraint is integrated within the inquiry of the application for authorisation (targeting articles R 214-1 to 31 of the Code of the Environment). An impact assessment is also necessary;

- According to the **code on public health**, which transposed the **EU Drinking Water Directive** into French law, there is a need to guarantee the quality of the water which is intended to human consumption. **Precaution measures** need to be taken in this sense as it is foreseen by the articles R 1321-22 and R 1321-3 of the code on public health. The code on public health puts also provisions in place to **control** the water foreseen for human consumption in the articles R 1321-15 and following. In addition, **quality standards** for drinking water are fixed for the following substances in the **decree from 11 January 2007**: Chlorine, limescale, lead, nitrates, pesticides and bacteria;

- The **chemical quality** of the water used for recharge is generally evaluated on the basis of **norms** which have been fixed by the "Conseil supérieur d'hygiène publique de France (CSHPF)" – a former French consulting organism. This implies that the nutrient content, the content of metal traces and the presence of pathogenic micro-organisms is evaluated. Depending on the water which is used, additional quality criteria will be considered, like the presence of pesticides, certain emergent organic substances or specific pathogenic species; and

- In France, annex n°86 of the report of the Senate on water quality and wastewater treatment (under the direction of Gérard Micquel, March 2003) clarify that **the use of wastewater for the artificial recharge of groundwater is prohibited in practice**.

Data on artificial groundwater recharge

There are no official statistics on artificial groundwater recharge in France. An **inventory** from the year 2013 (Casanova et al., 2013) listed **75 sites of artificial groundwater recharge on the French national territory**. The status of 48 out of them is known with certainty, without certainty for 8 and unknown for 19. Two-third of the sites for which the status is known are situated in the (former) regions Nord-Pas-de-Calais, Midi-Pyrénées and PACA. Only about **20 of them are still active** today (Casanova et al., 2013). The techniques applied are either indirect injection (infiltration basins) or direct injections (via drillings).[115]

In most of the known cases of artificial groundwater recharge in France, the primary **objective** is the **support to an overexploited groundwater body**. The second objective is the **improvement of the quality** of the groundwater bodies through significantly diminishing the concentrations of certain chemical elements by dilution (e.g. nitrates, pesticides). The latter allows for the application of simpler and more economic final treatments which make the water suitable for drinking water purposes.[116]

In almost all cases which are currently active in France, **surface water** is the **source of water used** for artificial recharge. This is mainly due to the availability of the resource. However, in addition to its quantitative availability, also the following reasons explain this predominance of surface water as a source: 1) The water has a chemical and microbiological quality which is correct, even in the absence of pre-treatment. This allows its use for quantitative and/or qualitative objectives. 2) Surface water can be used in the framework of different devices for artificial recharge, going from infiltration techniques or indirect injection

[115] BRGM, 2016

[116] Casanova et al, 2013

up to direct injection techniques. 3) The legal framework allowing the use of surface water for recharge is already established[117].

Given that the use of treated wastewater for artificial groundwater recharge is currently forbidden in France, this technique is not applied. While direct injection of treated wastewater in the aquifer has never taken place in France, two research projects on indirect infiltration of treated effluent have been carried out by BRGM – the public service provider for the quantitative groundwater management in France – and the company Veolia until 2011 (REGAL and RECHARGE)[118].

Current potential for using treated wastewater for aquifer recharge

Given the existing interdiction of using treated effluent for aquifer recharge, there is currently no potential for applying this measure in France. In addition, the overall abundance of water in the country and the availability of surface water as an alternative source for artificial recharge is limiting also the theoretical potential for applying the technique in the near future to only a few areas. Casanova et al. (2013) indicates furthermore that any use of treated wastewater for artificial recharge in France would require additional post-treatment.

Likely development

Discussions around artificial recharge, including by using treated effluent as a source, are taking place in the context of adaptation to climate change. The national plan on the adaptation to climate change 2011-2015 had foreseen that the French Agency for Food, Environmental and Occupational Health and Safety (ANSES) would evaluate the risks linked to reusing water for artificial groundwater recharge[119]. In its recommendations published in April 2016, ANSES[120] specifies that artificial recharge of groundwater with either surface water or treated wastewater is one of the solutions which could – under certain conditions – be applied as a measure against the decrease of groundwater resources. These conditions are the following:

- Artificial groundwater recharge shall neither degrade the water quality of the groundwater body, nor require – after extraction – additional treatment of the water for the same use compared to a resource which is not recharged;
- All groundwater which is subject to artificial recharge must be compatible – with their current or future use – with water production intended for human consumption, in order not to jeopardize these resources for the future; and
- The quality of the water used for recharge must be better or at least equivalent to the quality of the groundwater.

With regards to the use of treated wastewater for recharge, ANSES emphasises, however, that a change of regulation would be required prior to any application (as the use of wastewater for artificial recharge is currently not allowed).

The BRGM anticipates within the context of the current climate change a potential decrease of the natural recharge of the groundwater bodies, which could reach up to 50% in the most unfavourable cases. Artificial groundwater recharge (taking into account all potential water sources) is seen as one major type of advanced management of groundwater resources[121].

With regards to recent activities, a research project has been initiated by the BRGM and the Rhône-Méditerranée-Corse water agency at the end of 2015 in order to investigate the potential for artificial recharge in the river basin district. The objective was to map the favourable areas and to evaluate the feasibility in pilot areas. The characteristics of the soil and the groundwater body, the depth of the unsaturated zone, the status of groundwater body and the availability and quality of the surface water form

[117] Casanova et al, 2013
[118] BRGM, 2016
[119] http://www.developpement-durable.gouv.fr/IMG/pdf/PNACC_synthese-32p_MAJ_avril-2013.pdf
[120] ANSES (Agence nationale de sécurité sanitaire alimentation, environnement, travail) Risques sanitaires liés à la recharge artificielle de nappes d'eau souterraine – Avis de l'Anses – Rapport d'expertise collective. April 2016. Scientific edition. https://www.anses.fr/fr/system/files/EAUX2012SA0255Ra.pdf
[121] BRGM, 2016

part of the technical criteria which are considered. Economic and institutional dimensions will also be studied: identified water needs, seasonality of the needs or the costs of the measure (BRGM, 2016). This kind of information is considered as being indispensable for the further promotion of artificial recharge, including potentially with treated wastewater.

Health issues are of overriding importance in the discussions around the potential reuse of wastewater. Lengthy and complex investigations on the purification characteristics of the soil (by infiltration) on a local level are seen as indispensable before recharge activities can take place. Although artificial recharge might become more important in the future in France, the process is expected to advance rather slowly.

2.8 Aquifer recharge: proposal

Non-binding standards for water reuse

Given the current interdiction of using treated wastewater for groundwater recharge in France and the high importance given to the potential sanitary risks, it is not expected that non-binding standards for water reuse provided at European level will have any significant impact in the country. In the best case the promotion of non-binding standards might re-start discussions on the issue.

Legally binding standards for water reuse

As described above, in the current situation where the use of treated wastewater for artificial groundwater recharge is illegal, also legally binding quality standards would have no direct impact. However, it can be expected that such an initiative at European level would provide a good basis for discussions in the country. Taking into account the importance given to sanitary risks, legally binding standards at European level would probably remove some uncertainty around the issue and give some support to those favourable for using treated effluent for recharge. However, given that existing regulations regarding reuse for agricultural irrigation is rather seen as too stringent[122], it can be expected that potential national standards for the use of wastewater for recharge would anyway be at least as strict as the ones included in the draft JRC proposal. Also in the case of a future change in the French regulation which would make the artificial recharge with wastewater possible, legally binding rules at EU level would hence have only a limited impact for the French situation, where water quality standards are anyway set in a rather strict way.

Furthermore, with regards to the potential promotion of wastewater reuse through European standards, it is worth mentioning that the main barrier seen today in France is a technological / scientific one, linked in the case of artificial recharge to the difficulty to collect data on the self-purification capacity of soils. Casanova et al. (2013) clearly states that only once this barrier has been removed, a regulatory evolution is possible. Also the consideration of social, economic and environmental impacts will only take place afterwards. This provides another argument for saying that EU quality standards won't have an important positive impact on promoting water reuse for groundwater recharge in France, as it does not target the current main barrier.

Finally, the quality standards proposed by JRC seem to apply to the water which is used as a source for artificial recharge. The indicated required water quality would therefore be the one which is available after a specific post treatment of the water, before its actual use for recharge. In France, however, even if it is acknowledged that a specific post-treatment before reuse is needed[123], the main focus of research lies on the purification capacity of the soil, to ensure that the water has the correct quality once it has infiltrated in the soil. Requiring the correct water quality even before infiltration (as foreseen by JRC) is not consistent with the current reflections and research efforts undertaken in France. In this sense, the draft JRC proposal quality standards might lead to an additional barrier for introducing artificial groundwater recharge with wastewater, as potentially a more intense post-treatment is needed than the one considered today, which takes the purification capacity of the soil into account. It is worth mentioning, however, that the recommendations on artificial recharge recently published by ANSES124 also make reference to the quality of the water used for recharge, requiring that it should be better or at least equivalent to the quality of the groundwater body.

[122] BIO by Deloitte, 2015
[123] Casanova et al, 2013
[124] ANSES 2016

2.9 Aquifer recharge: impact assessment

Non-binding standards for water reuse

No impact is expected (see above). For this reason, an assessment of impacts was not conducted.

Legally binding standards for water reuse

Economic impacts	
Operating costs and conduct of business/Small and Medium Enterprises	As the option is mainly expected to relaunch discussions in the country, no relevant impact is expected on business and SMEs (e.g. water recycling plants). In case the French legislation will change to include aquifer recharge with treated wastewater (on the longer term), this will open up additional opportunities for water treatment companies, as well as promoting the creation of new ventures and companies. At the same time, existing water treatment/recycling companies (e.g. currently practicing water recycling for irrigation) will be likely to need to invest in additional treatment technologies, as quality requirements for treated wastewater for aquifer recharge are expected to be more stringent. On the other hand, if the discussion is relaunched private companies might start investing in research and development.
Administrative burdens on businesses	As the option is mainly expected to relaunch discussions in the country, no relevant impact is expected on business and SMEs (e.g. water recycling plants). In case the French legislation will change to include aquifer recharge with treated wastewater (on the longer term), companies wanting to adopt this practice will of course have legal obligations to fulfil (e.g. application for permits), but these additional costs will be compensated by revenues from the new practice.
Public authorities	As the option is mainly expected to support discussions in the country, no relevant impact is expected on public authorities. However, public authorities (e.g. Water Agencies, Ministry of Environment, ONEMA, public research institutes) might be willing to invest in research and studies, as well as in experimental testing. This will imply some costs, but it will also contribute to the creation of a valuable knowledge base on aquifer recharge with treated wastewater. In case water reuse for aquifer recharge will eventually be adopted by the French legislation (on the longer term), this will imply additional costs for the national administration, and in particular: (i) costs of developing the new law (background studies, legislative process including impact assessment); (ii) costs of adjusting the administrative system to implement the law (receiving and processing application, control of quality requirements, etc.).
Innovation and research	Re-opening the discussion on aquifer recharge with recycled water will definitely promote research and experimental testing of this practice, both by public authorities and universities and private actors.
Consumers and households	As the option is mainly expected to re-open discussions in the country, no relevant impact is expected on consumers and households. If the practice will be allowed by the French legislation and it will start being used in the country, the costs of recharging aquifers might be reflected in water users' bills. However, this might occur on the long term, and at present is not possible to say something more specific about the expected impacts on water bills.

Social impacts	
Employment and labour markets	The promotion of research and innovation on treatment technologies for aquifer recharge might increase the demand for qualified personnel in the field of wastewater treatment and recycling (private and public). Background studies on the introduction of this technology in France might involve contributions from private consultancies. If the practice will become legal in the country, additional jobs will be made available. However, in both cases it is very difficult to infer something more than qualitative about the possible impact on the labour market. It can reasonably be expected that water recycling for aquifer recharge will be a niche sector, so the macro-economic impact will be very limited (both in case of research and development of the topic that in case of future adoption of this practice). If the practice will become legal in the country, it can be expected that requirements will be very strict, and thus that the practice will have a limited adoption. Thus the impact on the labour market will again be limited.
Governance, participation, good administration, access to justice, media and ethics	The development of EU standards, as well as the consequent relaunch of discussions in the country, might bring the practice to the attention of the public. In addition, the existence of EU standards could positively steer public perception and acceptance of this practice.
Public health and safety	As the option is mainly expected to relaunch discussions in the country, no relevant impact is expected on public health and safety. Nevertheless, by promoting public debate and research on the topic, this option would indirectly increase knowledge on aquifer recharge with recycled water: research and experimental testing might improve existing technologies, also in terms of safety and thus public health. In case the practice will become legal in the country (on the longer term), it can be expected that quality standards will be very stringent, so no negative impacts on public health and safety can be expected.

Environmental impacts

Environmental impacts	
Water quality and resources	As the option is mainly expected to relaunch discussions in the country, no relevant impact is expected on water quality and resources. Even if the practice will become legal (on the longer term), quality standards are expected to be very stringent, so no negative qualitative impact can reasonably be expected. From a quantitative point of view, it must be recalled that the practice is unlikely to be widely adopted in France because the country is generally rich in water resources –among other reasons. However, the adoption of this practice on groundwater bodies with mediocre quantitative status might positively contribute in improving quantitative statues.
Renewable or non-renewable resources	For ground water, please see above.
The environmental consequences of firms and consumers	As the option is mainly expected to relaunch discussions in the country, no relevant impact is expected on sustainable production and consumption. On the longer term, if the practice becomes legal in France, it will contribute in increasing the sustainability of water and sanitation provision.

2.10 Aquifer recharge: Comparison of the alternative policy options

As previously illustrated:

- It is not expected that the introduction of EU non-legally binding standards (Option 1) will have an impact on the current national legislation –aquifer recharge with recycled water is currently forbidden. Thus, no relevant impacts are expected in the country; and
- The introduction of EU legally binding standards (Option 2) is likely to re-open policy discussions and public debate on aquifer recharge with recycled water. On the longer term, the country might decide to allow this practice, but it can be expected that requirements will be more stringent than European ones. Overall, the impacts of this policy option are expected to be limited.

Table 2.7 Synthesis table of impact assessment for aquifer recharge

	Non-binding standards for water reuse	Binding standards for water reuse
Overall economic impact	**0**	**0/+**
Operating costs and conduct of business/Small and Medium Enterprises	0	0/+
Administrative burdens on businesses	0	0
Public authorities	0	0
Innovation and research	0	+ +
Consumers and households	0	0/-
Overall social impact	**0**	**+**
Employment and labour markets	0	+
Governance, participation, good administration, access to justice, media and ethics	0	+
Public health and safety	0	0/+
Overall environmental impact	**0**	**0/+**
Water quality and resources	0	0/+
Renewable or non-renewable resources	0	0
The environmental consequences of firms and consumers	0	0/+

++ Significant positive impact

+ Mild positive impact

- - Significant negative impact

- Mild negative impact

0 No relevant impact

3. Greece

3.1 Greece: A Member State highly compliant with UWWTD, but with low uptake of water reuse

In Greece the theoretical long-term annual freshwater availability reaches 72,000 Mm^3.[125] Due to a range of technical and economic reasons the amount of freshwater readily available for abstraction and use is much lower. The annual freshwater abstractions constitute only 13% of the theoretical availability and they are estimated at 9,539 Mm^3.[126] Approximately 61% [127] of the abstractions comes from surface water bodies and 38% is abstracted from groundwater bodies, while almost 1% [128] comes from other sources, such as desalinated water or treated wastewater effluents. The major water user in Greece is irrigated agriculture, which accounts for 84% [129] of the total water use.

Water uses by the domestic sector, manufacturing, livestock breeding and energy production account for 14%, 2%, 1% and 1% respectively.[130]

Water resources are managed by companies or individuals and the type of water management varies significantly among the different water uses. Irrigation water is self-abstracted, usually through illegal boreholes, or supplied by small collective organisations, named TOEV/GOEV (Local/General Land Reclamation Organisations). Currently, there is no treatment for agricultural effluents.

Domestic water supply and sanitation services are provided by EYDAP in Athens and its suburbs, EYATH in Salonica and local municipal companies (DEYA) or municipal agencies in the rest of the country. Also, several arid Aegean islands supply themselves with freshwater which is transferred by ferries or operate municipal desalination plants. EYDAP is in close cooperation with them providing consulting services, training of staff and transfer of know-how.

The share of the population connected to public water supply amounts to 94% [131] (2007). This share falls down to 92% [132] (2012) with respect to the population which is connected to urban wastewater treatment with at least secondary treatment. In cases not covered by the UWWTD (agglomerations below 2000 p.e.), the population is serviced by individual systems.

By taking into account the ratio of the total annual freshwater resources per inhabitant (6,543 m^3 per capita), Greece can be considered a rather water poor European country. However it is not as water poor as other Mediterranean countries such as Malta, Cyprus, Italy and Spain (see figures below).

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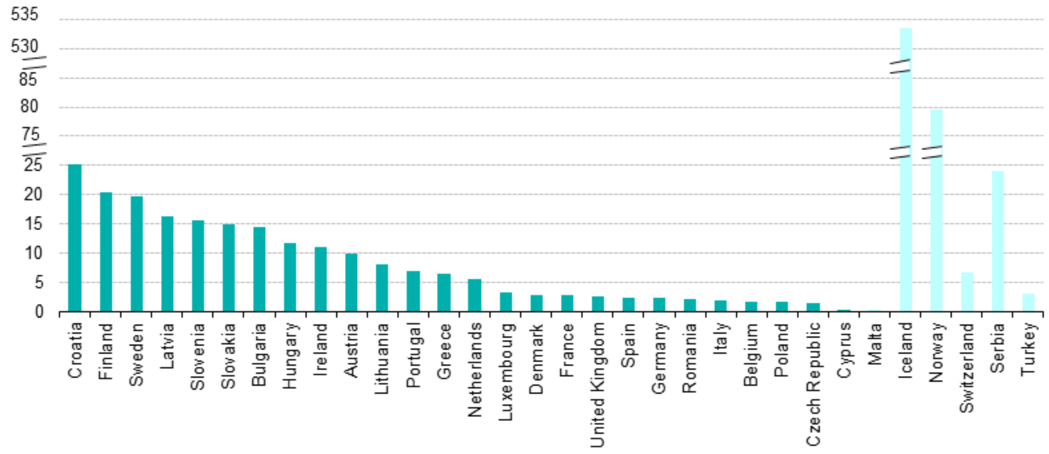
[125] Eurostat data, *Water statistics*
[126] Eurostat data, *Water statistics*
[127] Eurostat data, *Water statistics*
[128] Eurostat data, *Water statistics*
[129] Koutsoyiannis, D., Andreadakis, A., Mavrodimou, R., Christofides, A., Mamassis, N., Efstratiadis, A., Koukouvinos, A., Karavokiros, G., Kozanis, S., Mamais, D., and Noutsopoulos, K., 2008. *National Program for the Management and Protection of Water Resources*. Support to the development of the national program for the management and conservation of water resources, 748 pages, Department of Water Resources and Environmental Engineering, National Technical University of Athens, Athens
[130] Koutsoyiannis, D., Andreadakis, A., Mavrodimou, R., Christofides, A., Mamassis, N., Efstratiadis, A., Koukouvinos, A., Karavokiros, G., Kozanis, S., Mamais, D., and Noutsopoulos, K., 2008. *National Program for the Management and Protection of Water Resources*. Support to the development of the national program for the management and conservation of water resources, 748 pages, Department of Water Resources and Environmental Engineering, National Technical University of Athens, Athens
[131] Eurostat data, *Water statistics*
[132] Eurostat data, *Water statistics*

Figure 3.1 Total annual freshwater resources per inhabitant in 2011 (in 10^3 m^3)



(1) The minimum period taken into account for the calculation of long term annual averages is 20 years.
Population data are as of 1 January 2011; Estonia, not available; Ireland and Turkey, estimates.

Source: Eurostat [133]

By taking into account the results of the WEI+ indicator for the 2002 – 2012 period (CSI 018: Water Exploitation Index) [134] half of the Greek RBDs (7 out of 14) face water scarcity issues with a WEI+ above 20%. Furthermore, these 7 Greek RBDs are among the twenty most water scarce RBDs of Europe.[94135]

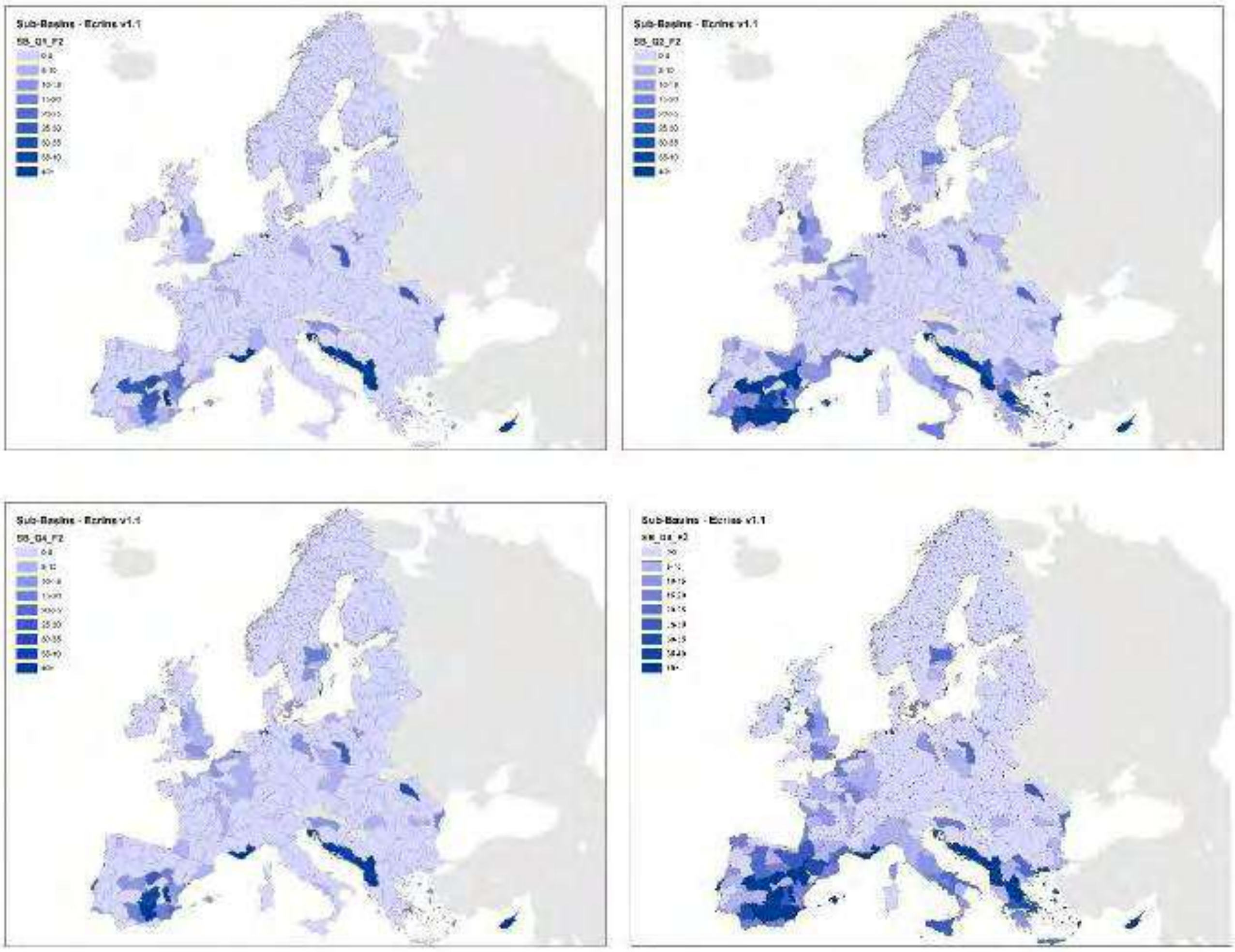
It should be highlighted that the freshwater resources in Greece are distributed unequally in space and time, causing serious imbalance of water availability on a seasonal and regional scale. In particular, the RBDs in Eastern Greece and the Aegean islands face more serious issues with water scarcity and drought than those in Western Greece, because the observed rainfall depths are much lower. In addition, irrigated agriculture and tourism, which are two basic economic activities for Greece, are responsible for a remarkable seasonal peak in water demand during the second and third quarter of the year, whereas the other water uses have minor seasonal fluctuation in water demand. As a result, the issue of water scarcity and drought is more evident during April-September than in October-March (see figure below).

133 Eurostat data, *Water statistics*

134 ETC/ICM, 2016. *Use of freshwater resources in Europe 2002–2012. Supplementary document to the European Environment Agency's core set indicator 018*. ETC/ICM Technical Report 1/2016, Magdeburg: European Topic Centre on inland, coastal and marine waters, 62 pp.

135 ETC/ICM, 2016. *Use of freshwater resources in Europe 2002–2012. Supplementary document to the European Environment Agency's core set indicator 018*. ETC/ICM Technical Report 1/2016, Magdeburg: European Topic Centre on inland, coastal and marine waters, 62 pp.

Figure 3.2 Seasonal WEI+ (Q1-Q4) at Ecrins Sub-Basin scale (LTAA for 2002-2012)



Note: *up* First Quarter (Q1: January–March); Second Quarter (Q2: April–June); *bottom* Fourth Quarter (Q4: October–December); Third Quarter (Q3: July–September)

Source: ETC/ICM[136]

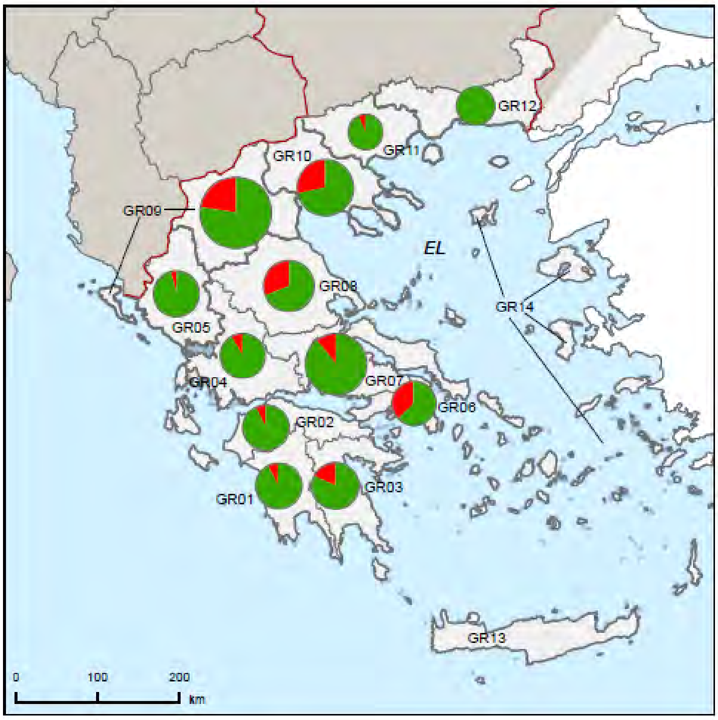
Processed data from the Greek RBMPs (2009-2015) [137] indicate that the overall status of approximately 30% of the surface water bodies is below good condition. The main activities putting pressure on the status of the water bodies are irrigated agricultural, urban sprawl and uncontrolled industrial emissions. Another 30% is in unknown state and is associated with insufficient monitoring. On the other hand, almost 80% of the Greek groundwater bodies are characterised in good state. Only 15% of them are in bad chemical state and 17% in bad quantitative state[138]. Bad chemical state is mainly related with diffuse nitrate pollution from agriculture and sea water intrusion in coastal areas. Bad quantitative state is mainly attributed to over-abstraction of non-renewable water resources to meet seasonal peaks in water demand. Bad quantitative state is more evident in those RBDs facing the biggest issues with water scarcity and drought.

[136] ETC/ICM, 2016. *Use of freshwater resources in Europe 2002–2012. Supplementary document to the European Environment Agency's core set indicator 018*. ETC/ICM Technical Report 1/2016, Magdeburg: European Topic Centre on inland, coastal and marine waters, 62 pp

[137] Processed data by the authors.

[138] COM, 2015. *WFD implementation report on River Basin Management Plans, MS: Greece*, Commission Staff Working Document accompanying the document Communication from the Commission to the European Parliament and the Council: "The Water Framework Directive (WFD) and the Floods Directive (FD): Actions towards the 'good status' of EU water and to reduce flood risks", European Commission, Brussels.

Figure 3.3 Water quantity status of groundwater bodies in Greek RBDs (RBMPs 2009-2015)



Note: *red* for bad state; *green* for good state
Source: EU Commission [139]

Potential for water reuse

The Greek Special Secretariat for Water was unable to provide concrete information on the current and potential wastewater reuse in Greece. Literature review shows that several pilot and operational projects have run in Greece.

The major water reuse sites can be found in Salonica, Heraclion, Hersonissos and Chalkida[140,141]. Unfortunately, the reported estimates for the current and potential volumes of reused wastewater differ significantly. The average daily wastewater reuse is estimated at 28,000 m^3/day (or 10.2 Mm^3/y)[142], while in the AQUAREC project the average annual wastewater reuse was estimated at 23 Mm^3/y[143]. The future potential for water reuse in Greece (2025) was modelled at 57 Mm^3/y[144] in the AQUAREC project, while another study estimated it at 242 Mm^3/y[145]. Generally, there is scepticism whether these estimates are

[139] COM, 2015. *WFD implementation report on River Basin Management Plans, MS: Greece*, Commission Staff Working Document accompanying the document Communication from the Commission to the European Parliament and the Council: "The Water Framework Directive (WFD) and the Floods Directive (FD): Actions towards the 'good status' of EU water and to reduce flood risks", European Commission, Brussels.

[140] Ilias, A., Panoras, A., and Angelakis, A., 2014. Wastewater Recycling in Greece: The Case of Thessaloniki. *Sustainability*, 6, pp. 2876-2892; doi:10.3390/su6052876

[141] Tsagarakis, K.P., Tsoumanis, P., Chartzoulakis, K., Angelakis A.N., 2001. Water resources status including wastewater treatment and reuse in Greece: Related problems and prospectives. *Water International*, 26, 2, pp. 252–258.

[142] Kellis M., Kalavrouziotis, I.K., and Gikas, P., 2013. Review of wastewater reuse in the Mediterranean countries, focusing on regulations and policies for municipal and industrial applications. *Global NEST Journal*, Vol. 15, No. 3, pp. 333-350.

[143] Hochstrat et al., 2006. *Report on integrated water reuse concepts*. Deliverable D19, AQUAREC project.

[144] Hochstrat et al., 2006. *Report on integrated water reuse concepts*. Deliverable D19, AQUAREC project

[145] Tsagarakis, K.P., Tsoumanis, P., Chartzoulakis, K., Angelakis A.N., 2001. Water resources status including wastewater treatment and reuse in Greece: Related problems and prospectives. *Water International*, 26, 2, pp. 252–258

reliable, because of the underlying assumptions in the calculation methodology. Both estimates for the reuse potential seem too ambitious in the current context, as it would be difficult to achieve this level of reuse in a cost-efficient way. [146]

In any case, the current water reuse conducted in Greece seems to be very low, when compared to the total water use in the country (below 1%). Furthermore, the share of reclaimed wastewater, when compared to the total treated effluent, is also extremely low (below 5%).[147] A water balance analysis has revealed that over 83% of the treated effluents is produced in regions with a water deficit. Furthermore, over 88% of the effluents from WWTP are discharged at less than 5 km from available farmland, which implies that the additional cost for wastewater reuse in irrigation could possibly be technically and economically affordable[148].

The key reasons why wastewater reuse could increase in Greece are the need for alternative water resources to deal with water scarcity and drought especially in eastern and southern Greece, the need to adapt to future climate change impacts on water resources, the need to raise water efficiency in irrigated agriculture by decreasing the extremely high freshwater use and the need to improve the quantitative state of the problematic groundwater bodies. Taking into account the very high compliance with the UWWTD in terms of wastewater collection and treatment, the remarkably high availability of treated effluents receiving more stringent treatment, the extremely low uptake of reuse technology and the fact that Greece is one of the few European countries which already have their own legal framework for wastewater reuse, it is plausible to assume that there is sufficient room to improve the national reuse uptake in the future.

This effort will require, though, significant action to address the current drawbacks, especially for the mobilisation of the proper regulatory, policy and economic instruments at national level and for the development of detailed studies, as integral part of the RBMPs, at regional level. Previous studies have identified the complexity and the high administrative burden for the application of the Greek reuse standards, as strong disadvantages blocking the increase of wastewater reuse in Greece. For example, the Greek standards apply strict limits for biochemical oxygen demand (BOD_5) and total suspended solids for urban uses, some industrial uses, unrestricted irrigation and aquifer recharge by wells. Some of these criteria are based on the Food and Agriculture Organization (FAO) recommendations on water quality for irrigation, with some modifications. The Greek standards are also stringent regarding E. Coli limit values, although they consider different numerical values for certain uses[149]. Moreover, technical and economic reasons also block further uptake of wastewater reuse. For example, the WWTP of Psyttaleia, which serves the broader capital area of Attica (35% of Greek population) could possibly contribute 20,000 m^3/day of treated effluent for landscape irrigation and industrial use, but the estimated cost (0.40 €/m^3) was not be found cost-effective in the current socio-economic context[150].

In general, since Greece is already highly compliant with UWWTD, there is a need now to focus on raising the uptake of water reuse in the country.

3.2 Wastewater collection and treatment

Greece is almost 100% compliant with Articles 3 (collection), 4 (secondary treatment) and 5 (more stringent treatment) of the UWWTD [151]. Overall, Greece has reported 492 agglomerations ≥ 2,000 p.e. with a generated load of 12,300,853 p.e (or 673 Mm^3/y). The majority of the agglomerations are connected to

[146] BIO by Deloitte, 2015. *Optimising water reuse in the EU*, Final report prepared for the European Commission (DG ENV), Part I. In collaboration with ICF and Cranfield University.
[147] TYPSA, 2012. *Wastewater reuse in the European Union*. Service contract for the support to the follow-up of the Communication on Water Scarcity and Droughts, Report for DG ENV.
[148] BIO by Deloitte, 2015. *Optimising water reuse in the EU*, Final report prepared for the European Commission (DG ENV), Part I. In collaboration with ICF and Cranfield University
[149] JRC, 2014. *Water reuse in Europe: Relevant guidelines, needs for and barriers to innovation*. JRC Science & Policy Reports.
[150] Ilias, A., Panoras, A., and Angelakis, A., 2014. Wastewater Recycling in Greece: The Case of Thessaloniki. *Sustainability*, 6, pp. 2876-2892; doi:10.3390/su6052876
[151] COM, 2016. *Eighth Report on the Implementation Status and the Programmes for Implementation (as required by Article 17) of Council Directive 91/271/EEC concerning urban waste water treatment*. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM (2013) 105 final, 4.3.2016, Brussels.

collections systems (10,336,974 p.e.). The rest are covered by individual and appropriate systems (IAS) or transport the wastewater with trucks to wastewater plants. From 165 agglomerations being due to secondary treatment, 132 agglomerations representing 96.4% of the targeted wastewater load meet the requirements. The wastewater load receiving secondary treatment is 9,750,018 p.e. From 18 agglomerations being due to more stringent treatment, 16 agglomerations covering 99.6% of the targeted wastewater load are meeting the requirements. The wastewater load receiving more stringent treatment is 6,535,070 p.e. Reported data indicate that 121 WWTPs comply with the requirements of the UWWTD for secondary treatment (96.4% of due load) and 15 WWTPs are comply with the requirements for more stringent treatment (99.6% of due load). It should be noted that secondary treatment is not compulsory for very small agglomerations (i.e. below 2,000 p.e.) if discharging into freshwaters and for bigger agglomerations (i.e. 2,000-10,000) if discharging into coastal waters. These cases are mostly covered by IAS. Overall IAS accounts for 16% of the generated load and is applied at 78% of the agglomerations[152].

Progressively, Greece aims to reduce the number of IAS where the urbanisation is sufficiently concentrated and is interesting to build collecting systems and treatment plants. Greek investments in collecting systems and treatment plants (new and renewal) are expected to reach 250 M € per year (~23 € per inhabitant) on average during 2015-2020 or 1,500 M € in total. The planned projects are expected to cover 5.3% (646,500 p.e. or 35.4 Mm^3/y) of the total load generated by all the agglomerations ≥ 2,000 p.e.[153]. Therefore, the cost-efficiency ratio of the planned projects is 7 €/m^3 of treated effluent.

Various technologies have been adopted in Greece for the treatment of urban wastewater, including activated sludge systems, natural systems and attached growth systems. Activated sludge systems are mainly comprised of extended aeration systems, conventional systems and sequencing batch reactors. Extended aeration is the dominant system, because it provides significant advantages for the Mediterranean climatic conditions[154].

Each water supply and sanitation company follows a local pricing policy, so there is a wide range of billing rates. The average price of domestic water for the 14 RBDs of Greece ranges between: 1.08-1.87 €/m^3 [155]. Taking into account the estimations for the 14 RBDs of Greece, the total cost recovery for domestic water ranges between 33 - 108%.[156] Only two RBDs (out of 14) achieve full cost recovery. In the other 12 RBDs the revenues of the water companies are considerably lower than the cost of the water services they provide. The sanitation services provided to customers are typically charged by applying a fixed rate to the total bill of water supply.

Wastewater reuse in Greece is regulated by two Joint Ministerial Decisions (JMD): JMD 145116/2011 (GG B 354) and JMD 191002/2013 (GG B 2220), which aim to promote wastewater reuse and protect public health by establishing criteria and standards on its practice. The scope covers: a) urban and conventional industrial wastewater (included in JMD 5673/400/97), for restricted and unrestricted irrigation in agriculture, urban and peri-urban use, aquifer recharge (including protected aquifers) and industrial use, b) unconventional industrial wastewater (excluded from JMD 5673/400/97), which is no longer hazardous, for restricted irrigation in agriculture, aquifer recharge (excluding protected aquifers) and industrial use. The recycling of industrial wastewater, the direct or indirect reuse for potable water, the reuse for bathing use (i.e. swimming pools) and the other household uses lie outside of the scope of the two JMDs.

The reuse of treated urban wastewater for agricultural irrigation may differentiate depending on the type of crops (e.g. food crops to be eaten raw, food crops to be cooked or processed, non-food crops, ornamental

[152] Tsagarakis, K.P., Tsoumanis, P., Chartzoulakis, K., Angelakis A.N., 2001. Water resources status including wastewater treatment and reuse in Greece: Related problems and prospectives. *Water International*, 26, 2, pp. 252–258.
[153] COM, 2016. *Eighth Report on the Implementation Status and the Programmes for Implementation (as required by Article 17) of Council Directive 91/271/EEC concerning urban waste water treatment*. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM (2013) 105 final, 4.3.2016, Brussels
[154] Tsagarakis, K.P., Mara, D.D., Angelakis, A.N., 1998. Evaluation of municipal wastewater treatment plants in Greece. *Tech. Chron.*, 18, pp. 97–109.
[155] Ministry of Planning, Environment and Public Works, 2008. *Implementation of the economic aspects of Article 5 of the Water Framework Directive 2000/60/EC in Greece*, Athens
[156] Ministry of Planning, Environment and Public Works, 2008. *Implementation of the economic aspects of Article 5 of the Water Framework Directive 2000/60/EC in Greece*, Athens

flowers), the irrigation equipment (sprinklers used or not) and the access status for the public and the animals (restricted or unrestricted). The Greek legal framework is summarised in Table 3.1.

Table 3.1 Greek legal framework for urban wastewater reuse in irrigated agriculture

Scope		**Agricultural irrigation**	
Applied crops		food crops to be eaten raw (e.g. raw vegetables, vines) ornamental flowers	food crops to be cooked or processed non-food crops (e.g. feed crops, industrial crops, pastures) crops with no ground contact during harvest (e.g. trees - *except fruit trees*) seeds
Irrigation equipment (sprinklers allowed: Yes/No)		Yes	No
Type of access to animals and public		unrestricted access	restricted access
Monitored parameters		Monitoring frequency (minimum required sampling and analysis)	
Microbiological: E.coli		2 or 4/week *	1/week
Physical-chemical:	**BOD_5, SS, Total N, Total P**	4 or 12 or 24/year *	
	Turbidity	2 or 4/week *	*not required*
Agronomic: ECw, TDS, SAR, Na, Cl, NO_3-N, HCO_3, pH		1 or 2/year *	
Heavy metals and metalloids: 19 elements		1 or 2 or 4 or 12/year *	
Priority substances: 41 substances		2/year	
Disinfectant residual (chlorine)		continuous	
Minimum required treatment		Secondary+Tertiary+Disinfection	Secondary+Disinfection
Key water quality standards			
E. Coli		≤5 EC/100ml (80% samples), ≤50 EC/100ml (95% samples)	≤200 EC/100ml
BOD_5		≤10 mg/l (80% samples)	≤25 mg/l
SS		≤10 mg/l (80% samples)	≤35 mg/l
Turbidity		≤ 2 NTU	not required

* depending on WWTP capacity (in p.e.)

The proposed frequency and the associated costs for the water quality analysis (microbiological, physical-chemical, chemical parameters) is given in Table 3.2. Based on literature[157] the most important issue, which has been reported in Greece with respect to the reuse of WWTP effluents for irrigation, is the increased level of salts. Generally, WWTPs located at coastal areas face salinity problems more frequently, likely due to seawater intrusion. Another issue, which has been mentioned in literature[158] is the high seasonal concentration of E. Coli, making WWTP effluents non-suitable for irrigation. In all cases, systematic monitoring, appropriate management practices or additional treatment can solve the issue.

[157] COM, 2015. *WFD implementation report on River Basin Management Plans, MS: Greece*, Commission Staff Working Document accompanying the document Communication from the Commission to the European Parliament and the Council: "The Water Framework Directive (WFD) and the Floods Directive (FD): Actions towards the 'good status' of EU water and to reduce flood risks", European Commission, Brussels

[158] Makropoulos, C., and M. Mimikou, 2012. A Monograph, Innovative approaches to halt desertification in Pinios: Piloting emerging technologies. i-adapt project, NTUA, Athens.

Table 3.2 Overview of costs for monitoring parameters

Parameter	Frequency	Cost
Legionella	+	High
E. coli and similar	+++	Very low
Enterococci (*Salmonella*)	+++	Low
Nematode eggs	++	Medium
Taenia	++	Medium
Giardia and *Cryptosporidium*	+	High
Bacteriophage	+++	Low
Enterovirus	+	High

Frequency: +++, permanently – weekly; ++, monthly – once per year; +, once per 1 – 5 year. Costs per analysis: very high, > 200 €; high, 60 - 200 €; medium, 20 - 60 €; low, 6 - 20 €; very low, < 6 €

Parameter	Example / indicators	Frequency	Costs
Physical-chemical	pH, EC, Turbidity, TSS, Colour	+++	very low
Organic sum parameters	COD (TOC, DOC), BOD, DO	+++	low
	AOX	+++	medium
Nutrients	Total-N, NH^{4+}-N	+++	low
Residual chlorine	Cl_2 (if chlorination)	+++	low
Physical-chemical	Sodium absorption ratio (SAR), UV 254	++	very low
Minerals	NO_3^-, SO_4^{2-}, Cl^-, Total-P	++	low
(Heavy) metals	As, Cd, Cr(III,VI), Hg, Pb, B	+	medium
Organic micropollutants	Surfactants, Mineral oil	+	medium
(Heavy) metals	Al, Ba, Be, Co, Cu, Fe, Li, Mn, Mo, Ni, Se, Sn, Th, V, Zn	□	medium
Organic micropollutants	Aldehyde, Phenols	□	medium
Pesticides	Diuron; 2,4-D	□	high
Complex-forming substances	EDTA	□	high
Chloride solvents	if AOX > limit, e.g. TCE	□	high
Aromatic organic solvents	Benzene	□	high
PAHs	Benzo(a)pyrene	□	high
Pharmaceuticals	Carbamazepine, X-ray contrast media, Sulfamethoxa-zole	□	very high
Endocrine disrupters	E-Screen	□	very high
Disinfection (by)products	NDMA	□	very high

Frequency: +++, permanently - weekly; ++, 1 – 2 per month; +, 2 per month - once per year; □, once per 1 – 5 year. Costs per analysis: very high, > 200 €; high, 60 - 200 €; medium, 20 - 60 €; low, 6 - 20 €; very low, < 6 €

Source: AQUAREC project [159]

[159] Salgot et al., 2006. *Guideline for quality standards for water reuse in Europe*, Deliverable D15, AQUAREC project.

3.3 Agricultural irrigation: baseline

Agricultural sector profile

Historically, agriculture has been one of the most important economic sectors and employers in Greece. Overall, the agricultural sector contributes roughly 4%[160] to the Greek economy in terms of GVA and accounts for 13.5% of the total employment.[161] The total utilised agricultural area (UAA) is 3,477,930 ha[162]. Arable land accounts for 51%, while permanent grassland and meadows (roughly grazing land) account for 22% of the UAA.[163]

The main cultivated crops are cotton, maize, wheat, tobacco, olives, vines, fruits and vegetables and the main animal products are milk, meat, cheese and honey. The main export products are live animals, food and beverages, tobacco, oils and fats. In 2014 the total value of the agricultural output was € 9.5 billion (values at producer prices)[164], while in 2013 the total agricultural exports reached € 4.8 billion[165].

The key details of Greek crop production in terms of acreage, volume, value and yields are given in Table 3.3 by type of crop. Estimations are rough based on aggregates of existing Eurostat categories for crops. The water productivity of the agricultural sector is 0.74 €/m^3 **[166]**.

Table 3.3 Crop production in Greece in 2015

Crop type	Acreage (106 ha)	Production (106 t)	Production value (106 €) d	Yield (t/ha)	Yield value (€/ha)
Food crops to be eaten raw a	1.33	8.45	4,731.6	6.37	3,569.5
Food crops to be cooked or processed b	1.07	5.62	1,158.1	5.24	1,080.2
Non-food crops c	1.37	1.50	1,191.1	1.09	869.0

Source: Eurostat [167]
[a] Eurostat categories: Fresh vegetables, melons, strawberries; Permanent crops for human consumption
[b] Eurostat categories: Cereals; Pulses; Root crops
[c] Eurostat categories: Industrial crops; Flowers and ornemental plants; Plants harvested green from arable land; Seeds and seedlings; other crops on arable land
[d] at producer price (current prices)

Agricultural irrigation

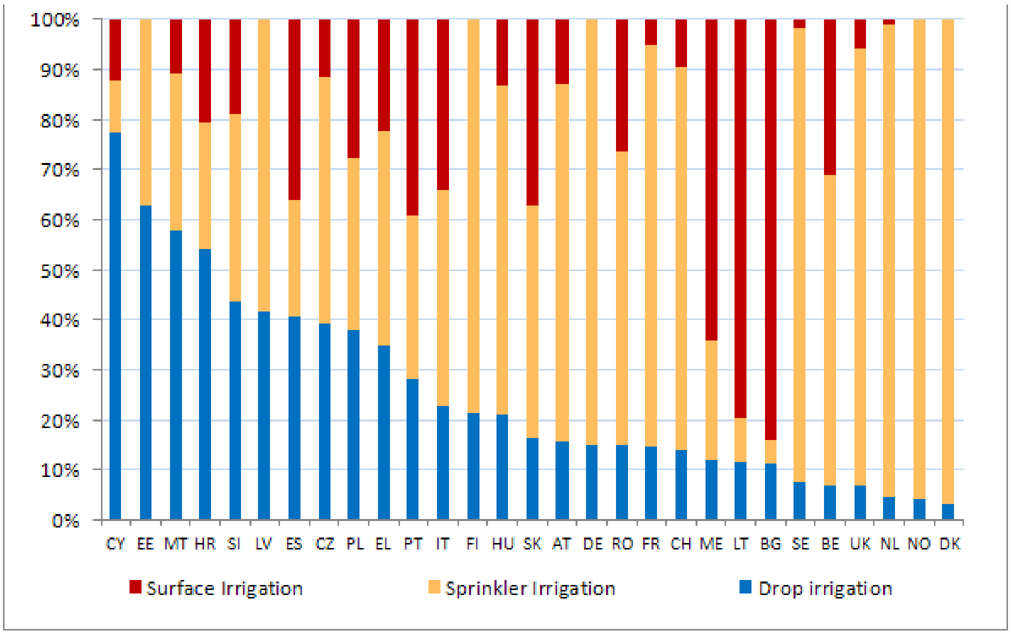
It is estimated that 84% of the total water use in Greece is taken up by irrigated agriculture (3,897 Mm^3). The average irrigation intensity is 3,800 m^3/ha, which is the 6th highest in Europe.[168] The high share of irrigation in the total water use is linked to the following facts. The irrigable area in Greece reaches 45% of UAA, while the irrigated area at least once a year is approximately 34% of UAA. In terms of shares of irrigable and irrigated area to total UAA Greece is on the top of all EU countries.[169] The share of irrigated land has increased rapidly since 1980s, from nearly 25% to 34%, as a result of EU subsidies on certain agricultural products (e.g. olives, cotton, durum wheat, sugarbeet). The emphasis on production led to the

[160] Hellenic Statistical Authority, *National Accounts, Labour market*.
[161] Hellenic Statistical Authority, *National Accounts, Labour market*
[162] Eurostat data, *Agricultural statistics, Crop statistics, Agri-environmental indicators, Agricultural Census in Greece*.
[163] Eurostat data, *Agricultural statistics, Crop statistics, Agri-environmental indicators, Agricultural Census in Greece*.
[164] Eurostat data, *Agricultural statistics, Crop statistics, Agri-environmental indicators, Agricultural Census in Greece*.
[165] Panhellenic Exporters Association.
[166] Estimation based on the ratio of the value at producer prices (in €) of the output in the agricultural sector in GVA and the volume (in m^3) of the water allocated to the sector.
[167] Eurostat data, *Agricultural statistics, Crop statistics, Agri-environmental indicators, Agricultural Census in Greece*.
[168] Eurostat data, *Agri-environmental indicators*.
[169] Eurostat data, *Agri-environmental indicators*.

overexploitation of water resources and the nitrate pollution of groundwater. After the 2003 CAP Reform a downward trend has been observed, due to the decoupling of payments from production. Nowadays, farmers receive annual subsidies from the EU based on past production levels. Direct and indirect EU payments for agriculture in Greece reached € 3.1 billion in 2011[170]. In addition, irrigation in Greece covers nearly 62% of the typical water needs of the cultivated crops[171]. This is comparable to other southern EU countries, but differs significantly when compared to other central and northern countries (e.g. Denmark: 12.5%).

Moreover, water abstraction volumes for irrigation purposes are increased, when the conveyance efficiency of the infrastructure or the application efficiency of the irrigation system is low. Open channels and trenches are still widely used for the conveyance of irrigation water. Such infrastructure normally causes higher water losses (e.g. leakages to groundwater, evapotranspiration), which could reach overall 10-30%, depending on the lining. Closed pipes are commonly used also. Losses are reduced to 5-10%, depending on ageing and clogging. Furthermore, Greece has a fair share of surface irrigation (e.g. furrows), which is the least water efficient irrigation system. Losses can reach 25% in this case. Sprinkler and drip irrigation are more efficient, with rough losses 15% and 10% respectively. Surface, sprinkler and drip irrigation account for 22%, 43% and 35% of the irrigated area respectively (see figure below). By comparing reported irrigation abstractions (roughly 8,000 Mm^3) with reported irrigation water use (almost 3,900 Mm^3) the overall water loss from the source to the plant is approximated at 51%. Another reason for high irrigation use in Greece is the high number of illegal boreholes. The authorities have failed to enforce the law, identify them and shut them down or at least control the abstraction volumes. Instead many of these unlicensed points of abstraction have been legalised by paying a fee, without taking into account the environmental pressure to the groundwater bodies. It should be noted, though, that the conveyance losses for self-abstracted water is expected to be minimised. Overall, irrigation water in Greece is reported to come from on-farm groundwater (28.1%), on-farm surface water (3.3%), off-farm surface water (20.2%) and off-farm water from water supply networks (42.9% - includes both surface water and groundwater) and other sources (5.5%).[172]

Figure 3.4 Share of irrigation methods in European countries in 2010



Source: Eurostat [173]

[170] Eurostat data, *Agricultural statistics, Crop statistics, Agri-environmental indicators, Agricultural Census in Greece*.
[171] Estimation based on the ratio of the volume of water used for irrigation (as reported in FSS-2010) and the typical water needs of the irrigated area at least once a year excluding kitchen gardens and area under glass (as reported by Eurostat).
[172] Eurostat data, *Agricultural statistics*.
[173] Eurostat data, *Agricultural statistics, Agri-environmental indicators.*

Irrigation water in Greece is billed in various ways (see table below). The average price ranges between 0.02-0.70 €/m^3 [174] for volumetric billing, 73-286.3 €/ha [175] for flat rates by crop type and 45-243.1 €/ha for flat rates by irrigation system[176]. There are no abstraction or pollution charges. Taking into account the estimations for the 14 RBDs of Greece the total cost recovery for irrigation water ranges between 1.8%-56.3% [177]. The price of self-abstracted groundwater can be roughly approached by using the electricity consumption for pumping. For an expected range of depths it could range between 0.02-0.03 €/m^3 [178]. The price of desalination water is 0.3-0.7 €/m^3 [179].

Table 3.4 Share of different types and methods for billing irrigation water in Greece

Type of billing	Share of land (%)	Method for billing	Share of land (%)
no charge	3.8	By crop type	23
flat rate	16.7	By land acreage	22
volumetric billing	25.0	By irrigation system (i.e. furrows, sprinkler, drip)	10
flat rate & volumetric billing	54.5	Combination for crop type and irrigation system	14
		Metering precise water use (in volume)	15
		Metering electricity use	6
		Counting irrigation time	8
		Counting number of trees (only for olive trees)	2

Source: Kalligaros (2004) [180]

The annual crop water need and the rough water productivity for various crops are given in Table 3.5.

Table 3.5 Annual crop water need for various crops in Greece

Crop type	Indicative crop water need (mm or 10 m3/ha)
Food crops to be eaten raw	
Fresh vegetables & melons	600-750
Fruit and berry plantations	550-700
Citrus plantations	450-600
Olive plantations	450-600
Vineyards	600-700
Food crops to be cooked or processed	
Cereals (excl. maize and rice)	350-550
Maize	650-800
Rice	1000-1300
Sugar beet	600-750
Stevia	600-750
Potatoes	550-700
Sunflower	550-700
Non-food crops	
Textile crops (e.g. cotton)	600-750

[174] Kalligaros, D., 2004. *The cost of irrigation water in Greece*, Postgraduate Thesis, Environmental Studies Department, University of the Aegean.
[175] OECD, 2010. *Agricultural Water Pricing: EU and Mexico*, http://www.oecd.org/eu/45015101.pdf
[176] OECD, 2010. *Agricultural Water Pricing: EU and Mexico*, http://www.oecd.org/eu/45015101.pdf
[177] Ministry of Planning, Environment and Public Works, 2008. *Implementation of the economic aspects of Article 5 of the Water Framework Directive 2000/60/EC in Greece*, Athens.
[178] Processed data by the authors
[179] Zotalis, K., Dialynas, E., Mamassis, N., and Angelakis, A.N., 2014. Desalination Technologies: Hellenic Experience, *Water*, *6*, 1134-1150; doi:10.3390/w6051134
[180] Kalligaros, D., 2004. *The cost of irrigation water in Greece*, Postgraduate Thesis, Environmental Studies Department, University of the Aegean.

Crop type	Indicative crop water need (mm or 10 m3/ha)
Alfalfa	700-900
Maize (animal feed)	650-800
Fodder crops	550-650
Temporary and permanent grass	650-750

Source: JMD 16/6631/2.6.1989 (GG B 428) (adjusted)

Table 3.6 Water productivity for various crops in Greece

Crop product type	Water productivity (€/m^3)
Food crops to be eaten raw	
Pomegranate	5.28
Artichoke	1.76
Vines (table grape)	1.62
Watermelon	1.31
Melon	1.29
Apple	1.28
Appricot	1.02
Kiwi	0.92
Peaches & Nectarines	0.80
Food crops to be cooked or processed	
Caulifower & Broccoli	16.64
Tomato (industrial)	3.70
Asparagus	2.16
Potato	1.71
Stevia	1.15
Olives (olive oil)	0.94
Maize	0.25
Wheat (durum)	0.16
Sugarbeet	0.23
Non-food crops	
Cotton	0.32
Alfalfa	0.24

Source: Processed data from Psomas (2012) [181]

Wastewater reuse for agricultural irrigation

Over the last years at least 9 wastewater reuse projects for crop irrigation have been implemented in Greece.[182] The most important project is that of EYATH in Salonica (2,500 ha; corn, cotton, sugarbeet, rice, alfalfa). The rest include: Heraclion (570 ha; vines, olive trees), Levadia (cotton, corn), Amfissa (olive trees), Nea Kallikratia (150 ha; olive trees), Chersonissos (270 ha; olive trees), Malia (150 ha), Archanes (33 ha; vines, olive trees) and Kos (210 ha; olive trees, citrus).

[181] Psomas, A., 2012. *Water resources management in Pinios river basin under climate and socio-economic change using the WEAP21 software*. Postgraduate thesis, IIPP Water resources Science and Technology, National Technical University of Athens, pp. 254.
[182] Ilias, A., Panoras, A., and Angelakis, A., 2014. Wastewater Recycling in Greece: The Case of Thessaloniki. *Sustainability*, 6, pp. 2876-2892; doi:10.3390/su6052876

A review of these reuse project suggest that wastewater reuse has already been implemented in Greece for a range of crops, but mostly for olive trees. The various projects address all types of crop products: crops to be eaten raw (grapes, olives, citrus), crops to be cooked or processed (rice, corn, wine, olive oil) and non-food crops (cotton, alfalfa).

A detailed review of two of these projects is included below.

Case Study 1: Salonica (most populated region of Northern Greece)

The most referenced case study is that of Salonica[183], where wastewater is treated using activated sludge and chlorination and the secondary effluent of the WWTP is mixed with freshwater from Axios river at a ratio of 1:5 to keep its quality within the Greek standards. The mixing is essential because the effluent has increased salinity, due to seawater intrusion into the sewerage system. Experimental and operational use of the treated effluents for irrigation of farms using surface and drip irrigation systems in the neighbouring Chalastra-Kalochori region has provided significant evidence on the associated risks and impacts.

Overall, the evaluation of the results indicates that treated wastewater can be safely used for irrigation without posing risk to the soils, crops, irrigation systems and human health, provided that the recommended practices are followed. However, only rational use of the effluent and systematic surveillance of the system ensures sustainability and long-term safety.

Regarding the crop yields, a key assumption drawn is that irrigation with freshwater or treated wastewater results in statistically similar yields for corn, rice and sugarbeet, while irrigation with treated wastewater results in higher yields for cotton. Also, surface and drip irrigation result in similar yields for cotton and sugarbeet, while surface irrigation increases corn yields by 10% compared to drip irrigation.

The reuse scheme in Salonica achieved reductions in fertilisers, because of the nutrient content of the treated effluents. The reclaimed water which was applied in rice fields contained 70-125 kg N/ha and 140-320 kg P/ha. Experiments showed that no additional fertilization was needed to achieve higher yields. The reclaimed water which was applied in the fields of corn, cotton and alfalfa contained 17-30 kg N/ha and 35-80 kg P/ha. Conventional fertilization for basic Greek crops is given in the table below. The key assumption is that the use of reclaimed water has reduced the need for fertilization with N and eliminated the need for fertilization with P, but mainly for P excessive loads may have been applied. This may have resulted in leaching of nitrates to groundwater bodies and the runoff of P and N to surface water bodies. Generally, irrigation with reclaimed water requires very careful design and monitoring. The transport of nutrients to the water bodies may degrade water quality, reduce biodiversity, cause eutrophication and result in health risks if these water resources are potable. In addition, increased concentration of nutrients, and particularly N, may significantly affect the growth and quality of irrigated crops. It may cause excessive vegetative growth at the expense of crop yield and lower accumulation of carbohydrates in sugarbeets and fruits.

Table 3.7 Conventional fertilization for various crops in Greece

Crop	Annual conventional fertilization	
	(kg N/ha)	(kg P/ha)
Wheat	131	16
Corn	214	48
Cotton	195	31
Alfalfa	0	46

Source: NAGREF [184]

The volume of reclaimed water used for irrigation in Salonica is reported [185] to range between 1.6-5.0 Mm^3/y, which is 2.8-8.7% of the average volume of treated effluents. State-controlled EYATH, which operates the

[183] Ilias, A., Panoras, A., and Angelakis, A., 2014. Wastewater Recycling in Greece: The Case of Thessaloniki. *Sustainability*, 6, pp. 2876-2892; doi:10.3390/su6052876

[184] Makropoulos, C., and M. Mimikou, 2012. A Monograph, *Innovative approaches to halt desertification in Pinios: Piloting emerging technologies*. i-adapt project, NTUA, Athens.

WWTP, charges no tariff to farmers for the reclaimed water it supplies. There is also no contract framing the transaction. It is carried out based on the annual approval of the General Assembly of the local Farmers' Association. The main obstacles, which were addressed during the project were related to administrative bureaucracy, reluctance of farmers and lack of public awareness. The establishment of the Greek standards in 2011 and the simplification for licensing in 2013 has partly solved the first issue. The second issue was addressed in practice, as trust, credibility and acceptance was built gradually between the company and the local farmers. It should be highlighted, though, that the economic benefit (free reclaimed water, no fertilization, potentially higher yields) is reported to be the key motivation for the farmers to cooperate. The third issue was partly dealt with public education campaigns and dissemination activities. Public acceptance and involvement is highlighted as a major issue for any similar project.

Case Study 2: Thessaly (major agricultural region in Central Greece)

The Pinios river basin is a key agricultural area in the region of Thessaly, in Central Greece. It faces severe issues with water scarcity and it has been designated as a Nitrate Vulnerable Zone (NVZ). Wastewater reuse was one of the emerging technologies which were studied during the i-adapt project, which was one of the DG ENV Projects to Halt Desertification in Europe. [186] A special study focused on wastewater reuse was conducted for the WWTPs of the 3 largest cities (i.e. Larissa, Karditsa and Trikala), as well as for 5 more WWTPs in the area.

The results show that reusing higher volumes of wastewater will require the construction of suitable storage tanks for the winter effluents, which in turn will increase the cost of the reuse scheme. Since cotton represents half of the irrigated area in the region and, as a non-food crop, gaining public acceptance for the project seems easier, the examined scenarios focused only on the irrigation of cotton farms in the vicinity of the WWTPs. The potential for wastewater reuse is estimated at 25 Mm^3/y (23 Mm^3/y for the 3 big cities) or 2-3% of the total annual irrigation abstraction. The total area which could be irrigated is 61,210 ha (55,950 ha for the 3 big cities). For restricted irrigation of cotton, the upgrade of existing WWTPs requires 0.003-0.019 €/m^3. Assuming drip irrigation for cotton fields, this would require the construction of closed pipes and the installation of drip irrigation systems costing 0.045-0.118 €/m^3. The construction of storage tanks will require 0,008-0,185 €/m^3. An additional cost for monitoring is expected, though not included in the analysis. The total cost of the scheme would range between 0.123-0.304 €/m^3. The most cost-efficient cases are the 3 big cities: Karditsa (0.123 €/m^3), Larissa (0.195 €/m^3) and Trikala (0.232 €/m^3). If the full cost is internalised, then the reclaimed water will be supplied to the farmers at the above prices. It should be highlighted, though, that a more accurate and integrated approach should also take into account the potential economic benefits for the farmers when using reclaimed water, such as the reduced cost for fertilisers (1.3 €/kg of N which was not applied) and the increased cotton yields (0.540 €/kg of increased cotton harvest, if any).

Taking into account both the average price of the irrigation freshwater in the Pinios river basin (0.03 €/m^3) and the actual monetary cost (0.06 €/m^3), none of the above cases seems capable of supplying reclaimed water to farmers in competitive prices. It is interesting, though, that the total cost of irrigation freshwater (including resource and environmental cost) reaches 0.339 €/m^3, which is significantly higher than the cost of reclaimed water for irrigation. Raising the price of the irrigation freshwater much higher, to achieve full cost recovery, seems rather a theoretical option. The strong opposition of the farmers would probably block such decision. Furthermore, a more detailed study is missing on the integrated impacts of a price increase.

Integrated modelling work conducted for the Pinios river basin suggests that wastewater reuse for the irrigation of cotton may be an optimal choice for 14 Mm^3/y of treated effluents. It has also been estimated that there is a net benefit for the farmers (0.26 €/m^3), when considering the total balance of costs and benefits and farm level [187].

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[185] Soupilas, A., Zambetoglou, K., Chantzi, E., Panoras, A., Papastergiou,F., 2012. *Agricultural re-use & reclamation of treated effluents: The experience of the Thessaloniki Wastewater Treatment Plant (Thessaloniki, Greece).* IWA Water Wiki. International Water Association.

[186] Makropoulos, C., and M. Mimikou, 2012. A Monograph, *Innovative approaches to halt desertification in Pinios: Piloting emerging technologies*. i-adapt project, NTUA, Athens

[187] Panagopoulos, Y., Makropoulos, C., Kossida, M., Mimikou, M., 2014. Optimal Implementation of Irrigation Practices: Cost-Effective Desertification Action Plan for the Pinios Basin. *Journal of Water Resources Planning and Management*, 140 (10).

Summary of the baseline

Climate and demographic change, possibly assisted by migration, are expected to increase the pressures on the Mediterranean water resources in the future, thus affecting Greece. Existing issues with water scarcity and drought will deteriorate, especially in Eastern Greece and the Aegean islands, where the majority of the population is located and the economic activities of farming and tourism are more intense. Demand for water is expected to rise. Since irrigated agriculture accounts for 84% of the total water use and irrigation covers 62% of the annual water needs of the cultivated crops, water shortages in this sector and crop losses are expected to increase. This will raise concern on water availability and water use efficiency. Public discussion and scientific research will focus on the sustainability and competitiveness of the agri-food sector.

Furthermore, WFD objectives are poorly managed in Greece, as nearly 30% of the water bodies is not in good state and another 30% is in unknown state. Additional measures and additional resources will be needed to comply fully with WFD, as well as with the rest directives, policies and strategies in the domain of water and environment. For example, the quantitative status of 15% of the groundwater bodies and the chemical status of 17% of the groundwater bodies need to be improved. Many of them lie in agricultural regions and within Nitrate Vulnerable Zones, as their issues are associated with unsustainable agricultural practices. Therefore, improving their status will require reductions in the current water and nutrient use in irrigated agriculture.

Wastewater reuse has a record of saving water and nutrients. Taking into account the techno-economic and regulatory restrictions, it can be applied in regions with water and nutrient balance problems. Especially in Greece, wastewater reuse is particularly low, when compared to the total treated effluent (below 5%) or the total water use in the country (below 1%). In addition, a water balance analysis has revealed that over 83% of the treated effluents is produced in regions with a water deficit. Furthermore, over 88% of the effluents from WWTP is discharged at less than 5 km from available farmland, which implies that the additional cost for wastewater reuse in irrigation could possibly be technically and economically affordable.

Moreover, Greece is highly compliant with the UWWTD in terms of wastewater collection and treatment (almost 100%) and there is remarkably high availability of treated effluents receiving more stringent treatment (>50%). This means that the additional treatment costs to reach wastewater reuse standards could be minimised. It is highlighted that Greece is one of the few European countries which already have their own legal framework for wastewater reuse, recently established in 2011 (amended in 2013). In case no EU-level instrument on water reuse is proposed, Greece is expected to keep its own framework active. Minor amendments are expected, not impacting the current spirit of the law. Previous studies have identified the complexity and the high administrative burden for the application of the Greek reuse standards, as strong disadvantages blocking the increase of wastewater reuse in Greece. For example, the Greek standards for unrestricted irrigation apply strict limits for biochemical oxygen demand (BOD_5), total suspended solids (TDS) and pathogens (E. Coli).

It is expected that future reuse projects will focus on restricted irrigation of non-food crops (e,g, cotton, alfalfa), crops to be cooked or processed (rice, corn and sugarbeet) and crops with no ground contact during harvest (e.g. olive trees, vines and citrus). This is based on the current experience from existing case studies and eventually it reflects the categorisation of the Greek reuse standards. The aforementioned crop types belong in the same category, which requires less strict water quality standards for irrigation. Public acceptance is also more flexible on these crop types. For this type of irrigation, sprinklers are not allowed. Therefore, the available farms are only those performing drip irrigation. Currently, the share of drip irrigation in the total irrigated land is 35%. Due to lack of economic resources technological transition to more efficient irrigation systems will be slow and this share is not expected to change substantially.

Since the monetary cost of (usually illegal) self-abstracted on-farm surface water and groundwater is very low (<0.03 €/m^3), these users will not be interested to use reclaimed water. This is at least 32% of the total holdings. Taking into account the price of desalination water (0.3-0.7 €/m^3) it is concluded that wastewater reuse might be more cost-efficient than desalination in coastal areas and islands with existing WWTPs. It is also expected that reclaimed water would be appealing to users of off-farm surface water and off-farm water from supply networks, which account for nearly 63% of the total users. Given that the existing irrigation freshwater tariffs range significantly across the country (0.02-0.70 €/m^3) and reported price of reclaimed water ranges from 0 (Salonica case study) to 0.12-0.30 €/m^3 (Pinios case study), there is not sufficient data to make the comparison between the two types of water. Price competitiveness relies on the local context and the analysis requires more detailed approaches. It should be noted that the current water tariffs do not achieve full cost recovery (1.8-56.3%), but the price of irrigation freshwater is not expected to increase much in the future. In any case, a price increase may not guarantee a significant reduction in water abstractions, since this depends on the elasticity of water demand, but partially it will provide incentives to shift from freshwater to reclaimed water. The (initial) promotion of reclaimed water would be feasible if there was no charging for the farmers (as happens in Salonica) or if the charging was equal or less to the price of irrigation freshwater. This is in line with the experience from Cyprus, where the average rates for reclaimed irrigation water range from 33-41% of the freshwater rates[188].

Evidence from studies[189, 190] indicates that the perception of risk may greatly influence the willingness of producers and consumers of agricultural products to use and pay for reclaimed water and crop products irrigated with reclaimed water. Some users demonstrate completely inelastic behaviour, which means that there are certain social barriers for the uptake of wastewater reuse, while others are more flexible and their behaviour is influenced by their level of knowledge for the associated costs and benefits. Price difference is also an important matter for many producers and users, since they tend to consider reclaimed water and products which integrate reclaimed water as not equal with freshwater and freshwater-related products. A combination of awareness campaigns, education, better standards and pricing policy could increase the level of public acceptance[191]. However, in the baseline such action is assumed to have only fair results. This can be partially attributed to the relative lack of recycling attitude, compared to other EU communities. Another reason is the bad record in the rate of adoption of environmental solutions, due to strong local opposition and court disputes (e.g. waste management and landfills, installation of windfarms).

Overall, technical, economic and social reasons will continue to block faster uptake of wastewater reuse for agricultural irrigation in the baseline. Additional wastewater reuse might come from the WWTPs where it is already implemented and potentially from some more new sites in Crete. A conservative estimate is that wastewater reuse in irrigated agriculture will increase by 10-20% up to 2025[192].

3.4 Agricultural irrigation: proposal

The draft JRC standards refer only to urban wastewater, whereas the Greek standards also refer to conventional industrial wastewater.

In addition, JRC standards follow a different conceptual structure, which places emphasis on risk management and risk assessment. They introduce the concept of multiple barriers-preventive measures (e.g. wastewater treatment, on-farm management) leading to log reductions of risk for public health.

The scope of the JRC standards includes viruses, protozoa and bacteria, whereas Greek standards only cover bacteria (i.e. E. Coli). It is interesting that JRC also recognises the growing issue of antibiotic resistant bacteria, by adding tetracycline or cefotaxime resistant E. Coli among the monitored parameters. Almost all of the remaining parameters are already covered by the Greek standards. Slight changes include the addition of Boron in the list with the agronomic parameters and a change of unit in the measurement of sodium, chloride and bicarbonate.

A review of the tables for crop irrigation shows that drip irrigation is more preferable than sprinklers in general, because it ensures higher log reduction of health risk. Similarly, restricted access is mostly recommended for all farms irrigated with reclaimed water. The combination of drip irrigation and restricted access is capable of reducing the health risks significantly, thus allowing for less strict water quality standards. This also influences the cost of the required treatment, because the process may require less

[188] BIO by Deloitte, 2015. *Optimising water reuse in the EU*, Final report prepared for the European Commission (DG ENV), Part I. In collaboration with ICF and Cranfield University
[189] Menegaki, A.N., Hanley, N., Tsagarakis, K.P., 2007. The social acceptability and valuation of recycled water in Crete: A study of consumers' and farmers' attitudes, *Ecological Economics*, vol. 62(1), 7-18.
[190] Tsagarakis, K.P., and Georgantzis, N., 2003. The role of information on farmers' willingness to use recycled water for irrigation. *Water Science and Technology: Water Supply*, 3(4), 105-113.
[191] BIO by Deloitte, 2015. *Optimising water reuse in the EU*, Final report prepared for the European Commission (DG ENV), Part I. In collaboration with ICF and Cranfield University
[192] Agrafioti, E., Diamadopoulos, E., 2012. A strategic plan for reuse of treated municipal wastewater for crop irrigation on the Island of Crete, *Agricultural Water Management*, 105, 57-64.

stages or less intensity. The Greek standards are already much stricter than the proposed standards for E. Coli, while for TSS and BOD_5 both standards are close.

For the purpose of this review of impacts it is assumed that:

- The irrigation of *food crops to be eaten raw* requires benchmark quality for reclaimed water A ("very high quality");
- The irrigation of *food crops to be cooked or processed* requires benchmark quality for reclaimed water B ("high quality"); and
- The irrigation of *non-food crops* requires benchmark quality for reclaimed water C ("good quality").

Greek standards for food crops to be eaten raw already require secondary treatment, advanced treatment and disinfection and the minimum threshold values for all monitored parameters are much stricter than those of reclaimed water quality A.

Greek standards for food crops to be cooked or processed already require secondary treatment and disinfection, while the minimum threshold values are much stricter for E. Coli than those of reclaimed water quality B. Threshold values are close, but less stricter, for TSS and BOD_5. The draft JRC standards also provide a scenario of less stringent wastewater treatment (no disinfection) for certain crops and management practices in this category. It refers to food crops heavily processed, well-cooked or having no contact to the ground (e.g. grapes for wine production, cereals, potatoes, beetroots, fruit trees).

Greek standards for non-food crops already require secondary treatment and disinfection and the minimum threshold values are much stricter than those of reclaimed water quality C. JRC standards do not require disinfection for this category.

Non-binding standards for water reuse

This policy option introduces a non-legally binding document (e.g. Guidance or Recommendation), which stipulates minimum quality requirements for the use of reclaimed water in agricultural irrigation.

The Greek standards are generally stricter than the JRC proposal. In addition, although the Greek standards have been described as complex and blocking the uptake of reuse in Greece, the proposed framework by JRC is not less complex. In fact, the Greek standards can be considered more easily understandable, as they contain less categories and reference tables. Therefore, since the instrument is not mandatory, it is foreseen that Greek authorities will not adopt the new guidance/recommendation or at least they will consider making a few marginal changes, such as adding some new analytical parameters/processes. Adding tetracycline or cefotaxime resistant E. Coli and Boron in the Greek standards will have a low impact on the total cost for monitoring and it is not expected to cause any change in the level and cost of effluent treatment.

This development is further supported by the fact that Greece has a bad record of transposing and implementing EU environmental and water policy timely. It should be highlighted that Greece still lags behind in the implementation of WFD and FD, although significant efforts have been made since 2010 to close the initial gap with the other countries.

Legally binding standards for water reuse

This policy option introduces a legally binding document (i.e. Regulation) setting out quantifiable minimum water quality requirements that must be complied with when using reclaimed water in agricultural irrigation. It includes specifying eligible sources of wastewater that can be used for irrigation and risk management measures that must be complied with.

The Greek standards are generally stricter than the JRC proposal so the Greek authorities are more likely to keep the existing legal framework with some improvements because of the new features that the JRC proposal initiates. It is expected that new parameters, such as tetracycline or cefotaxime resistant E. Coli and Boron, and emerging contaminants will be added in the list of monitored parameters. This is expected to have medium impact on the total cost for monitoring and it is not expected to cause any change in the level and cost of effluent treatment. Since the scope of the draft JRC standards only includes the urban wastewater, it remains to be clarified if conventional industrial wastewater will continue to be reused in Greece and under what legislation. Currently wastewater reuse seems to be more expensive than other freshwater sources. Therefore, higher overall costs for treatment and monitoring are expected to harm its competitiveness to some extent.

3.5 Agricultural irrigation: assessment of key impacts

Non-binding standards for water reuse

The situation in Greece will look similar to the baseline, as Greece will keep a similar legal framework to the existent. The costs for monitoring and treatment will be similar to the current. Public acceptance is expected to be positively affected after the publication of the instrument, but only to a limited degree. It is not expected that this development will be broadly communicated or discussed in depth.

Legally binding standards for water reuse

The situation in Greece will look similar to the baseline, as Greece will keep a similar legal framework to the existent with the addition of several parameters currently not covered. Therefore, the costs for monitoring and treatment will increase to the current. Public acceptance is not expected to be affected, as consumers and businesses will not see significant change to the current situation.

3.6 Agricultural irrigation: Comparison of the alternative policy options

The Greek framework differs a lot conceptually from the JRC proposal and it is already stricter. It is expected that the Greek authorities will not be keen to make deep structural changes if it is not mandatory for them to follow. In any case, they will try to meet the minimum requirements by making small revisions to the current framework to include several parameters not covered (e.g. tetracycline or cefotaxime resistant E. Coli, Boron or emerging contaminants). Therefore, both legal options look similar in terms of water reuse uptake and impacts in comparison to the baseline.

3.7 Aquifer recharge: baseline

Groundwater resources

In Greece, the average annual groundwater availability for abstraction is reported at 3,550 Mm^3.[193] The abstraction from groundwater resources accounts for 38% of the total water abstractions. Groundwater is a primary source for drinking water in rural areas and for the industrial sector. It is also a significant source of water for irrigated agriculture, which covers 84% of total water use. Almost 80% of the Greek groundwater bodies are in good state. Only 15% of them are in bad chemical state and 17% in bad quantitative state[194]. Bad chemical state is mainly related with diffuse nitrate pollution from agriculture or sea water intrusion in coastal areas and islands. A large number of groundwater bodies in the lowlands have been designated as Nitrate Vulnerable Zones (e.g. Thessaly, Kopaida, Argolis) under Nitrates Directive. Metals and other traces have also been found, probably associated with industrial pollution or natural content of the hydrogeological formations. Bad quantitative state is mainly attributed to over-abstraction of non-renewable water resources to meet seasonal peaks in water demand. Bad quantitative state is more evident in those RBDs facing the biggest issues with water scarcity and drought.

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[193] Eurostat data, *Water statistics, Agricultural statistics, Crop statistics, Agri-environmental indicators, Agricultural Census in Greece*.

[194] COM, 2015. *WFD implementation report on River Basin Management Plans, MS: Greece*, Commission Staff Working Document accompanying the document Communication from the Commission to the European Parliament and the Council: "The Water Framework Directive (WFD) and the Floods Directive (FD): Actions towards the 'good status' of EU water and to reduce flood risks", European Commission, Brussels.

It should be highlighted that the majority of the groundwater systems in the lowlands are used for potable water use. In total 89 protected areas for drinking water have been designated under DWD. It is reported that 95.5% of them is in good state and 4.5% is in unknown state.[195]

Aquifer recharge

The reuse of treated urban wastewater for aquifer recharge is differentiated depending on the type of the aquifer (potable or non-potable water resources) and the applied method (direct injection in boreholes and wells or surface spreading and infiltration). It should be highlighted that direct injection of reclaimed water is not allowed for aquifers with potable water resources. Additionally, a hydrogeological study is required in all cases. The Greek legal framework is summarised in Table 3.8.

Table 3.8 Greek legal framework for urban wastewater reuse in aquifer recharge

Scope		**Aquifer recharge**		
Type of aquifer		potable water resources**	non-potable water resources**	
Applied method		surface spreading	direct injection	surface spreading
Monitored parameters		Monitoring frequency (minimum required sampling and analysis)		
Microbiological:	**E.coli**	not required	not required	1/week
	TC	2 or 7/week *	3 or 7/week *	not required
Physical-chemical:	**BOD5, SS, Total N, Total P**	4 or 12 or 24/year *		
	Turbidity	2 or 4/week *	2 or 4/week *	not required
Heavy metals and metalloids: 19 elements		1 or 2 or 4 or 12/year *		
Priority substances: 41 substances		2/year		
Disinfectant residual (chlorine)		continuous		
Minimum required treatment		Secondary +Advanced method (membranes) +Disinfection	Secondary +Advanced method (membranes) +Disinfection	Secondary +Disinfection
Water quality standards				
E. Coli		not required	not required	≤200 EC/100ml
TC		≤2 EC/100ml (80% samples), ≤20 EC/100ml (95% samples)	≤2 EC/100ml (80% samples), ≤20 EC/100ml (95% samples)	not required
BOD5		≤10 mg/l (80% samples)	≤10 mg/l (80% samples)	≤25 mg/l
SS		≤2 mg/l (80% samples)	≤2 mg/l (80% samples)	≤35 mg/l
Turbidity		≤ 2 NTU	≤ 2 NTU	not required

* depending on WWTP capacity (in p.e.) ** hydrogeological study is required

Reported data on aquifer recharge were not found in Eurostat or in the “National Program for the Management and Protection of Water Resources”[196]. After communication with the Special Secretariat for

[195] COM, 2015. *WFD implementation report on River Basin Management Plans, MS: Greece*, Commission Staff Working Document accompanying the document Communication from the Commission to the European Parliament and the Council: "The Water Framework Directive (WFD) and the Floods Directive (FD): Actions towards the ‘good status’ of EU water and to reduce flood risks”, European Commission, Brussels.
[196] Koutsoyiannis, D., Andreadakis, A., Mavrodimou, R., Christofides, A., Mamassis, N., Efstratiadis, A., Koukouvinos, A., Karavokiros, G., Kozanis, S., Mamais, D., and Noutsopoulos, K., 2008. *National Program for the Management and Protection of Water Resources*. Support to the development of the national

Water, the Greek authorities could not provide additional information on similar projects. Literature review revealed only two cases of aquifer recharge in Greece. Both were/are conducted in the context of research projects and serve as pilot sites. It is interesting that both of them are actually wastewater reuse projects. A few feasibility studies have been funded in the past by the Greek authorities (Directorate General of Reclamation Works) to investigate the potential for aquifer recharge. Unfortunately, limited information is available for them in terms of technology, cost and affordability. However, it seems that none of them has shifted to operational level [197].

Case study 1: Salonica (coastal aquifer for non-potable water use in Northern Greece) [198, 199, 200]

During the GABARDINE project (2007-2009) Managed Aquifer Recharge (MAR) was performed for a coastal, highly-permeable, sandy aquifer in the area of Sindos, Salonica, which lies in Northern Greece. The aquifer is used for non-potable water resources nowadays, because it has stopped supplying potable water since 2003, and suffers from sea water intrusion. The aquifer system extends to depths between 30 m to 120 m and aquifer permeability is relatively high, ranging between 6.7×10^{-4} m/sec and 2.55×10^{-3} m/sec. Wastewater from the WWTP of Sindos was treated using two membrane-based processes, microfiltration (MF) and reverse-osmosis (RO). Reclaimed water was recharged into the aquifer using surface spreading in two infiltration ponds. No cost data are available for this application.

After the GABARDINE project, further experimental work was conducted (2011-2012). Again, the two membrane-based processes, microfiltration (MF) and reverse-osmosis (RO), were used for wastewater treatment. This time wastewater reuse involved direct injection in boreholes. It is reported that the production and injection of 1 meter of osmotic water to the artificial recharge borehole cost approximately 2.6 kWh/m^3 in terms of energy consumption, which can be translated into 0.15 €/m^3. It should be highlighted, though, that this cost does not include the costs for installing the appropriate equipment.

Case Study 2: Lavrion (coastal aquifer for non-potable water use near Athens) [201,202]

During the MARSOL project (2013-2016) Managed Aquifer Recharge (MAR) is being performed for a coastal, alluvial and karstified aquifer in the area of the Technological Park of Lavrion, which is near Athens. The aquifer is used for non-potable water resources and suffers from sea water intrusion and over-abstraction for irrigation purposes. Reclaimed water from the WWTP of KELM is being transported with vehicles and recharged into the aquifer using surface spreading in infiltration basins. The Soil-Aquifer-Treatment (SAT) system is being employed. No cost data are available for this application.

A rather old study [203] has estimated that the average cost for groundwater recharge using reclaimed water of low treatment and surface spreading would cost 0.07 €/m^3 for a WWTP with capacity of 40,000 m^3/day or 0.17 €/m^3 for a WWTP with capacity of 4,000 m^3/day. Similarly, groundwater recharge using reclaimed water of advanced treatment and direct injection would cost 0.76 €/m^3 for a WWTP with capacity of 40,000 m^3/day or 2.12 €/m^3 for a WWTP with capacity of 4,000 m^3/day.

program for the management and conservation of water resources, 748 pages, Department of Water Resources and Environmental Engineering, National Technical University of Athens, Athens.

[197] Drosos, E., Tsarbos, V., Paschalinos, I., 2006. Artificial aquifer recharge for water management in agriculture, *Water Resources and Agriculture*. Hellenic Hydrotechnical Association Meeting, 2.2.2006. Hellenic Hydrotechnical Association, Salonica.

[198] EYATH, eyath.gr

[199] Azizur Rahman, M., Ptak, T., Nödler, K., Licha, T., Dimitriadis, K., Soupilas, A., Sauter, M., 2009. Influence of aquifer properties on water quality changes during infiltration of treated effluent, *Achieving groundwater supply & reliability through Managed Aquifer Recharge*, Proceedings of the Symposium ISMAR 7, International Symposium on Managed Aquifer Recharge, Abu Dhabi, 9-13.10.2009, United Arabian Emirates.

[200] Argyropoulos, G.N., Spachos, Th., Zampetoglou, K., Soupilas, Ath., Papadakis, N., Grammatikopoulos, G., 2013. *Pilot scale study of advanced wastewater treatment processes by EATH S.A.*, Conference paper.

[201] EYDAP, eyadap.gr

[202] MARSOL project, www.marsol.eu

[203] Asano, T., 1998. *Wastewater reclamation and reuse*. Water Quality Management Library, 10 CRC Press, Boca Raton, Florida.

The key technical risks which often block aquifer recharge from being implemented or lead in failures during implementation are the following:

- Direct injection requires higher water quality, which increases the total cost;
- Surface spreading requires availability of suitable land;
- Hydrogeological conditions do not favour recharge (e.g. slow process, karstic water losses); and
- Reclaimed water quality may cause clogging in the aquifer, due to high content of solids.

Summary of the baseline

Climate and demographic change, possibly assisted by migration, are expected to increase the pressures on the Mediterranean water resources in the future, thus affecting Greece also. Existing issues with water scarcity and drought will deteriorate, especially in Eastern Greece and the Aegean islands, where the majority of the population is located and the economic activities of farming and tourism are more intense. Demand for water is expected to rise. Water shortages in all sectors and associated economic losses are expected to increase. This will raise concern on water availability and water use efficiency. The use of non-conventional water resources (e.g. wastewater reuse) will attract greater interest in public discussion and scientific research.

Furthermore, WFD objectives are already poorly managed in Greece, as nearly 30% of the water bodies is not in good state and another 30% is in unknown state. Additional measures and additional resources will be needed to comply fully with WFD, as well as with the rest directives, policies and strategies in the domain of water and environment. For example, the quantitative status of 15% of the groundwater bodies and the chemical status of 17% of the groundwater bodies will need to be improved. Many of them lie in agricultural regions and within Nitrate Vulnerable Zones, when their issues are associated with unsustainable agricultural practices, or in coastal areas and islands, when their issues are associated with sea water intrusion. Therefore, raising their tables and fighting back intrusion through available technologies is expected to improve their state.

Aquifer recharge using reclaimed wastewater is capable of replenishing water resources in the groundwater, storing water resources for later use and partly reversing the impacts of sea water intrusion. Especially in Greece, wastewater reuse is particularly low, when compared to the total treated effluent (below 5%) or the total water use in the country (below 1%). In addition, a water balance analysis has revealed that over 83% of the treated effluents is produced in regions with a water deficit.

Moreover, Greece is highly compliant with the UWWTD in terms of wastewater collection and treatment (almost 100%) and there is remarkably high availability of treated effluents receiving more stringent treatment (>50%). This means that the additional treatment costs to reach wastewater reuse standards could be minimised. It is highlighted that Greece is one of the few European countries which already have their own legal framework for wastewater reuse, recently established in 2011 (amended in 2013). In case no EU-level instrument on water reuse is proposed, Greece is expected to keep its own framework active and follow the already adopted requirements under EU Drinking Water Directive 98/83/EC, Groundwater Directive 2006/118/EC and Water Framework Directive 2000/60/EC. Minor amendments are expected, not impacting the current spirit of the law. Previous studies have identified the complexity and the high administrative burden for the application of the Greek reuse standards, as strong disadvantages blocking the increase of wastewater reuse in Greece. For example, the Greek standards for apply strict limits for biochemical oxygen demand (BOD_5), total suspended solids (TDS) and pathogens (E. Coli).

Greek standards do not allow surface spreading for recharging aquifers for potable water. In addition, they are stricter in the case of aquifers for potable water using surface spreading or non-potable water using direct injection (secondary, advanced treatment and disinfection), than in the case of non-potable water using surface spreading (secondary treatment and disinfection). Therefore, the first two options will require much higher costs for treatment, which makes them less competitive. Generally, the costs are expected to be lower for surface spreading than direct injection, but the main issue with surface spreading is that it can be applied only when stretches of suitable land are available. Also, restricted access must be ensured in these areas afterwards.

The current wastewater reuse in Greece does not include any aquifer recharge projects. It has only been implemented in one site and there is another ongoing site. Both of them, though, are at pilot scale. Not much information is documented, especially on associated risks and costs. It is interesting that a few feasibility studies were conducted in the past, but none of them provides cost data or seems to have shifted to operational. After communication with the Special Secretariat for Water, the Greek authorities could not provide additional information on similar projects. Experience from the existing pilot sites also shows, that potential recharge projects would initially focus on aquifers used for non-potable water resources.

For a WWTP of 4,000 m^3/day the estimated cost for aquifer recharge is at least 0.17 €/m^3 to 2.12 €/m^3. When using treatment with microfiltration or reverse osmosis, then the cost of electricity could be 0.15 €/m^3. A newer abstraction from the recharged aquifer for indirect use would require an additional cost for pumping. Hence, the whole chain of costs would increase further. On the other hand, wastewater reuse in agricultural irrigation could cost 0.44 €/m^3 [204](or 0.123-0.304 €/m^3 in Greek case study 2). Generally there is a lack of concrete economic data, but reuse for aquifer recharge seems to be less mature and less competitive than reuse for agricultural irrigation in Greece.

This is further supported by the fact that the majority of the groundwater systems in the lowlands are used for potable water use. Overall 89 protected areas for drinking water have been designated under DWD across Greece. Since WWTPs are also located in lowland areas, it is likely that the water resources in the vicinity of the WWTP are intended for human consumption. Therefore, the required treatment costs would be high or recharge would not be allowed by Greek standards. Moreover, limestones cover a significant part of Greece. It is expected that karstic systems, especially found in limestones of coastal areas, will further decrease the potential for aquifer recharge with reclaimed water.

Public perception is going to be a major issue for recharging aquifers for potable water resources. Strong local opposition and court disputes are expected to be encountered[205].

Overall, technical, economic and social reasons will continue to block faster uptake of wastewater reuse for aquifer recharge in the baseline. Operational wastewater reuse might come from the WWTP of Salonica, where it has already been implemented. Very limited expansion is expected for aquifer recharge using reclaimed water.

3.8 Aquifer recharge: proposal

JRC standards refer only to urban wastewater, whereas the Greek standards also refer to conventional industrial wastewater. A review of the proposed standards shows that they are loosely described missing appropriate detail and clarity. They also make references to existing EU water legislation (i.e. WFD, DWD and GWD), which is already adopted by Greek legislation. The two standards differ significantly regarding the categories of reclaimed water, the monitored parameters and the foreseen level of treatment for each category.

By JRC, reclaimed water quality for water recharge is distinguished only by the type of aquifer. The two categories of water are:

- Recharge of aquifers which are *used as a potable water source* (DWD, GWD, WFD); and
- Recharge of aquifers which are ***not** used as a potable water source* (GWD, WFD).

By the Greek standards, reclaimed water quality is determined based on the combination of the type of aquifer and the type of the application method. As a result, the JRC proposal permits direct injection for potable aquifer recharge, but the Greek standards do not permit this method. Also, the JRC proposal

[204] Asano, T., 1998. *Wastewater reclamation and reuse*. Water Quality Management Library, 10 CRC Press, Boca Raton, Florida.
[205] Note that there in Greece is a long record of legal disputes regarding infrastructural projects (including environmental projects). Where groups of citizens and mayors usually oppose to projects the legal system allows for judicial reviews. The court decisions might delay for years, while the projects remain on hold. This has been the case for dams, hydropower stations, wind farms, landfills, tunnels and highways and could be reasonably expected for aquifer recharge project.

foresees different water quality categories for the combinations of surface spreading/potable water and direct injection/non-potable water, which are considered in the same category for the Greek standards. Based on the JRC proposal the first combination has to comply with stricter standards than the second.

Overall, the key differences are the following:

- The reclaimed water for the potable aquifer recharge will comply with DWD, GWD and WFD, whereas for non-potable aquifer recharge DWD will not be needed; and
- Another new element in the JRC proposal is the inclusion of contaminants of emerging concern (CECs) (e.g. biocides, hormones, pharmaceuticals, personal care products) for monitoring before potable or non-potable aquifer recharge. Such substances are not included in the Greek standards.

It is important to highlight that both standards require a hydrogeological study to be conducted to specify the local recharge scheme.

- For potable aquifers the JRC proposal stipulates stricter limits, following the DWD. Since the Greek standards already require secondary, advanced treatment (membranes) and disinfection the additional costs for treatment are not significantly higher;
- The Greek standards included only 1 parameter for the monitoring of the pathogens (either TC or E.Coli), whereas the JRC standards include 5. The Greek standards are less strict, because they recognise that the soil acts as a barrier retaining contaminants. Therefore, the reclaimed water which is recharged using infiltration could have lower quality than drinking water;
- Furthermore, the Greek standards include limits for suspended solids and turbidity to address the risk for clogging during aquifer recharge. JRC standards do not make any explicit reference on this matter;
- Overall the monitoring burden seems similar for both standards, but the monitoring cost is expected to be lower for the Greek standards, because they include more parameters with low to very low cost (see tables below), whereas the draft JRC standards require more parameters with high to very high cost; and
- Implementation of the JRC standards for potable water means higher cost for monitoring and treatment, than the Greek standards.

For non-potable aquifers the JRC standards look simpler and less strict than the Greek standards. There are no parameters for microbiology (very low cost) and organics (low cost), less physical-chemical parameters (TSS, turbidity - very low cost) and less metals (medium cost). But it adds several new physical-chemical parameters (nitrates, chlorides, sulphate, conductivity - low cost) and it includes CECs (high and very high cost). Overall the monitoring burden seems similar, but the monitoring cost is expected to be lower for the Greek standards. Required treatment is lower for the JRC standards, as disinfection is not implied. Greek standards for non-potable water require secondary treatment and disinfection or secondary, advanced treatment and disinfection. Also, JRC standards do not make any explicit reference on this issue of clogging. Implementation of the JRC standards for non-potable water means higher cost for monitoring and lower cost of treatment. The total cost is assumed similar to the Greek standards.

Non-binding standards for water reuse

This policy option introduces a non-legally binding document (e.g. Guidance or Recommendations) stipulating minimum quality requirements for using reclaimed wastewater for aquifer recharge. Specified water quality standards are determined based on the end-use, i.e. whether the aquifer is used as a source of potable water or non-potable water. Different end-uses require different levels of protection (with environmental compliance standards as a minimum), i.e. the standards proposed will not compromise the objectives and requirements of GWD, WFD and DWD. The proposed non-mandatory Guidance or Recommendation also stipulates sources of wastewater that would be applicable to reuse, and a range of risk management measures.

The Greek standards differ significantly in concept from the standards proposed by JRC. They are different regarding the categories of reclaimed water, the monitored parameters and the foreseen level of treatment for each category. In some aspects the Greek standards seem to be more stringent, but they could also be seen as more inclusive in terms of examined risks (e.g. clogging, pathogens, combinations of aquifer type and application method). In a few cases the Greek standards are less strict than the JRC standards (e.g. potable use/surface spreading). The analysis shows that the adoption of the JRC standards would result in higher cost for monitoring and treatment for potable aquifers and similar total cost for non-potable aquifers.

Since the instrument is not mandatory, it is foreseen that Greek authorities will not adopt the new guidance/recommendation or at least they will consider making a few marginal changes, such as adding some new analytical parameters. For example, adding CECs in the Greek standards will increase the cost for monitoring. This development is further supported by the fact that Greece has a bad record of transposing and implementing EU environmental and water policy timely. Actually, Greece has been taken to the European Court for several important delays and infringements of EU environmental policy. It should be highlighted that Greece still lags behind in the implementation of WFD and FD, although significant efforts have been made since 2010 to close the initial gap with the other countries.

Legally binding standards for water reuse

This policy option introduces a legally binding document (i.e. Regulation) setting out minimum quality requirements for water reuse to recharge aquifers used to provide potable supply and those that are not. Specified water quality standards are determined based on the end-use, i.e. whether the aquifer is used as a source of potable water or non-potable water. Different end-uses require different levels of protection (with environmental compliance standards as a minimum), i.e. the standards proposed will not compromise the objectives and requirements of GWD, WFD and DWD. It also specifies applicable risk management measures and monitoring and evaluation requirements.

The Greek standards differ significantly in concept from the standards proposed by JRC. They are different regarding the categories of reclaimed water, the monitored parameters and the foreseen level of treatment for each category. In some aspects the Greek standards seem to be more stringent, but they could also be seen as more inclusive in terms of examined risks (e.g. clogging, pathogens, combinations of aquifer type and application method). In a few cases the Greek standards are less strict than the JRC standards (e.g. potable use/surface spreading). Overall, the minimum water quality standards required for reclaimed water by the JRC proposal are higher than the current Greek standards. This is because the Greek standards assume that the reclaimed water will be filtered by the soil layers before reaching the target water body, whereas the JRC proposal requires high water quality before the initiation of the recharge. The analysis shows that the adoption of the JRC standards would result in higher cost for monitoring and treatment for potable aquifers and similar total cost for non-potable aquifers.

Since the instrument is legally binding and the Greek standards do not generally meet the minimum requirements, the Greek authorities will need to follow the European standards. Probably this will be done with delay, as Greece has a bad record in transposing environmental policies, including water policies. Actually, Greece has been taken to the European Court for several important delays and infringements of EU environmental policy. It should be highlighted that Greece still lags behind in the implementation of WFD and FD, although significant efforts have been made since 2010 to close the initial gap with the other countries. Since the scope of the JRC standards only includes the urban wastewater, it remains to be clarified if conventional industrial wastewater will continue to be reused in Greece and under what regulation.

3.9 Aquifer recharge: assessment of key impacts

Non-binding standards for water reuse

The situation in Greece will look similar to the baseline, as Greece will keep a similar legal framework to the existent. No further uptake of reuse in aquifer recharge is foreseen, because serious technical, economic and social reasons limit its potential to expand in Greece. The costs for monitoring and treatment might increase from the baseline, due to the addition of new parameters (e.g. CECs). Public acceptance is not expected to be affected after the publication of the instrument. It is not expected that this development will be broadly communicated or discussed in depth.

Legally binding standards for water reuse

The situation in Greece will look quite similar to the baseline. The adoption of the JRC proposal will tend to favour non-potable aquifer recharge, because the associated costs are expected to be lower and the public acceptance is expected to be higher. Therefore, a few more pilot sites are expected to operate in Greece, mostly in coastal areas facing issues with water scarcity and saline intrusion. Although a new framework will be adopted for wastewater reuse in aquifer recharge, little further uptake of reuse is foreseen. This is because serious technical, economic and social reasons limit its potential to expand in Greece. This is further supported by the fact that Greek standards are already in place, but this has not affected the uptake rate of the technology substantially. Moreover, the costs for monitoring will increase, but the costs for treatment will decrease from the baseline. As a result, the total cost is expected to be similar to the baseline. Public acceptance is expected to be influenced positively after the publication of the instrument, mostly for non-potable aquifers, but also for the potable aquifers (compliance with DWD).

3.10 Aquifer recharge: Comparison of the alternative policy options

For the non-legally binding instrument the costs for monitoring will be increased, in order to include several new parameters (e.g. emerging contaminants). For the legally binding instrument additional treatment costs will be needed to meet the minimum water quality standards and increased monitoring costs are foreseen to cover all the necessary parameters. The legally binding instrument will perform better in terms of improvement of public perception, since it follows a rather strict approach and ensures common minimum standards among all countries. The reuse uptake is not expected to rise, because of technical, economic and social reasons, regardless of the legal status of the policy option.

4. Italy

4.1 Italy: Potential for further water reuse with little uptake so far

Overview of water use

Water abstraction makes up for 31% of available water resources, and it is much above OECD average. Italy can thus be classified as a medium-high water-stressed country[206]. Water used by main sector can be summarized as follows:

- Nearly 50% of water abstraction is operated by the agricultural sector. In the last decades, water demand for agriculture has decreased, and it is projected to remain stable at around present levels in the future[207];
- 19% of abstracted water is used by households. Water abstraction for domestic water supplies, mostly from groundwater, has increased[208]. Domestic water consumption decreased by 17.8% in the period 2000-2012. This can be attributed, on the one hand, to an increased efficiency of domestic devices and, on the other hand, to a larger awareness of the economic value of water[209]; and
- 17% of abstracted water is used by industry, and 15% for cooling purposes in energy production. Water use by industry has declined since the early 1990s, whereas water use for energy production has increased[210].

Water stress, water scarcity and drought

Despite an average annual rainfall of 1 000 mm/year, well above European average, **average freshwater availability** for the population (2 900 m^3/capita) is **one of the lowest among OECD countries**, due to high evapotranspiration, rapid run-off and limited storage capacity[211]. In addition, available resources are distributed very unevenly across the national territory: 59.1% are in fact in the North, whereas the rest is shared by the Centre (18.2%), the South (18.2%) and the islands (4.5%).

In general, large disparities exist between the North and the South: with changing climate and precipitation patterns, also water management challenges vary across regions. Overall, the North enjoys relatively stable and abundant flows in water courses throughout the year, whereas in the South long periods without precipitations, resulting in drought and water rationing, are quite common. Also the hydrological regime is different: large river basins are fed by the Alps in the North, whereas the Apennine Mountains are characterized by many watercourses with irregular outflow paths. In the South, the river network is sparse, and the surface water deficit is compensated by increasing use of groundwater resources and water transfers among regions. Groundwater distribution is also uneven: around 70% of available groundwater resources are located in the North, in the alluvial plains, whereas far lower volumes are available in the South[212].

With regards to the water exploitation index, the only available data for Italy was recorded in 1998 with a WEI of 36.3%. There are no more recent records available[213].

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206 OECD, 2013. “OECD Environmental Performance Reveiws – Italy 2013”. OECD Publishing. http://www.keepeek.com/Digital-Asset-Management/oecd/environment/oecd-environmental-performance-reviews-italy-2013_9789264186378-en#page4

207 OECD, 2013

208 OECD, 2013

209 Autorità per l’energia elettrica, il gas e il sistema idrico (AEEGSI), 2014. Relazione annuale sullo stato dei servizi e sull’attività svolta. March 31, 2041. http://www.autorita.energia.it/allegati/relaz_ann/14/RAVolumeI_2014.pdf

210 OECD, 2013

211 OECD, 2013

212 OECD, 2013

213 http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tsdnr310&plugin=1

Water is relatively scarce in the country, especially in Southern regions. Water scarcity and droughts phenomena affects, in particular, the agricultural sector, as this sector contributes for over 50% of total water abstraction in the country[214]. However, issues with water availability are exacerbated by many factors other than scarce precipitation, such as illegal abstraction, obsolete irrigation networks, their scarce maintenance and the inadequacy of some storage systems[215].

Water quality in Italy

Water stress and, in some cases, over-abstraction is one of the major water management issues in the country.

In the reference period 2008-2011 groundwater made up for almost 50% of water abstracted for domestic water supplies[216]. Overexploitation has been reported in the North, in the lower reaches of the Po plain and around Venice, due to industrial and agricultural uses as well as gas and oil extraction. In some regions, the economic viability of farming is undermined by groundwater abstraction above recharge rates[217]. One of the main drivers of the over-abstraction of available resources by all sectors (domestic, industry and agriculture) is the high population density. The consequences of over-abstraction are widespread, and include water scarcity events, desertification risk in vulnerable areas and salty water intrusion in coastal areas[218]. Water availability differs significantly from Northern to Southern Italy. In the North, water is relatively abundant, due to stable and abundant flows in water courses throughout the year. In addition, out of 13 billion m^3 of groundwater available annually, over 70% is located in the North, and particularly in the Po river plain. In contrast, the South of Italy is often subject to long periods without precipitation, resulting in droughts and water rationing[219].

Overall, river quality has improved in recent years. In particular, concentrations of phosphorous and nitrates in rivers have decreased, due to a reduced intensity of agricultural production. Low river quality is often localized, and found in medium and small streams draining areas with large urban or industrial centres[220]. The industrial sector, with frequent uncontrolled wastewater discharges, puts a major pressure on water quality: 500 industrial plants are considered to pose a risk on the environment, 60% of which are in the North. Besides wastewater discharge, contamination is also due to industrial solid waste, which reaches 50 Gkg/year on average, of which 10 classified as toxic. Domestic solid waste (15 Gkg/year on average) also contributes to this situation. Contamination from solid waste disposal is exacerbated by the fact that disposal capacity for the domestic and industrial sector is only 18% of total production, resulting in illegal waste transport and storage[221]. However, also in the case of river pollution, differences among the North and the South exist, with rivers in the North performing generally better in terms of water quality[222].

Overall, surface and groundwater quality has improved in recent year due to the reduction of industrial pollution, investments in sanitation and better agricultural practices. However, the analysis included in RBMPs reveal that 36% of surface water bodies and 11% of groundwater bodies will not reach good status by 2015, but rather in 2021 or 2027[223].

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214 OECD, 2013

215 Dipartimento per lo Sviluppo e la Coesione Economica (DPS), 2014. “Accordo di partenariato 2014-2020 – Italia – Sezione 1°”. Conforme all’articolo 14 del Regolamento UE N.1303/2013 – Settembre 2014.

216 ISTAT, 2012. « Giornata Mondiale dell’Acqua – le statistiche dell’ISTAT ». Statistiche Focus, ISTAT. http://www.istat.it/it/archivio/57514

217 OECD, 2013

218 Direzione Generale dello Sviluppo Rurale, Infrastrutture e Servizi (DGSRIS), 2007. “Contributo tematico per l’aggiornamento del Piano Strategico Nazionale relativamente alla nuova sfida – Gestione delle risorse idriche”. Task-force tematica “Ambiente e Condizionalità”, Rete Rurale nazionale 2007-2013.

219 OECD, 2013

220 OECD, 2013

221 DGSRIS, 2007

222 OECD, 2013

223 OECD, 2013

Water reuse potential

Both industrial and domestic wastewater are treated, and reuse is mainly in agricultural irrigation and industry[224].

A survey of Italian treatment plants estimated the total treated effluent flow at 2,400 Mm3 per year of usable water. In view of the regulatory obligation to achieve a high level of treatment, the medium to large-sized plants (>100,000 inhabitants served), accounting for approximately 60% of urban wastewater flow can provide re-usable effluents for a favourable cost/benefit ratio.

Treated wastewater is used mainly for agricultural irrigation covering over 4,000 ha. However, the controlled reuse of municipal wastewater in agriculture is not yet developed in most Italian regions and has decreased due to the low quality of water.

The total cost (construction, operation and maintenance) for reclamation, in addition to the costs for the distribution of reclaimed water and the monitoring of the whole reuse system, will be difficult to attain and will be probably tolerable only for large WWTPs, thus reducing the benefit of reclaiming water and hampering the development of wastewater reuse practices for the smaller ones; moreover, several successful reuse activities operating since a few years in small communities of Southern Italy inland areas, will certainly be obliged to face problems difficult to cope with[225].

Following the adoption of the Law-decree n. 152, a new legislative set of rules was promulgated on June 12th, 2003 (Ministry Decree, D.M. no 185/03). Recycled water can be used for[226]:

- Irrigation of crops for human and animal consumption, as well as non-food crops. Irrigation of green and sport areas;
- Urban uses: street washing, heating and cooling systems, toilet flushing; and
- Industrial uses: fire control, processing, washing, thermal cycles of industrial processes (recycled water cannot get in contact with food, pharmaceutical products and cosmetics).

In the Decree 185/2003, a complete approach was used regarding the water quality parameters and there was the possibility for the Regional Authorities to change some parameters and implement stricter norms. The proposed standards followed a quite restrictive approach, especially for some chemical compounds: in many cases the quality standards for reclaimed wastewater were the same as drinking water. This approach led to some difficulties in promoting water reuse, when the compliance with some very strict standards required advanced treatments, with all the related consequences on the cost and financial sustainability aspects of the reclamation.

Another negative aspect is the overabundance of parameters taken into account and their related monitoring protocols. In fact the number of parameters to be monitored exceeds 50 items and the sampling frequency can be very high, depending on the regional provisions. It must be also considered that no regulatory distinction was established among various crops to be irrigated with reclaimed wastewater (restricted, unrestricted irrigation) and no attention was paid to the influence of different irrigation options (i.e.: subsurface drip irrigation, versus spray irrigation) in reducing sanitary risks. In summary: in a set of 54 control parameters - which is probably too large to assure an effective enforcement and monitoring - 20% of them ask for the same quality of drinking water; 37% of them are not even considered for drinking water, and the indication of some other parameters (for instance biocides and pesticides) is difficult to be explained in an agricultural environment.

Under these conditions, the total cost (construction, operation and maintenance) requested for reuse, in addition to the costs for the distribution of reuse water and the monitoring of the whole reuse system, are difficult to attain and will be probably tolerable only for large WWTPs, thus reducing the benefit of reclaiming water and hampering the development of wastewater reuse practices for the smaller ones; moreover,

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[224] BIO by Deloitte (2015) Optimising water reuse in the EU – Final report prepared for the European Commission (DG ENV), Part I. In collaboration with ICF and Cranfield University. http://ec.europa.eu/environment/water/blueprint/pdf/BIO_IA%20on%20water%20reuse_Final%20Part%20I.pdf

[225] Angelakis et al. (2007) Wastewater recycling and reuse in EUREAU countries – Report for EUREAU

[226] Agenzia per la Protezione dell'Ambiente e per i Servizi Tecnici (APAT), 2008. Il riutilizzo delle acque e dei fanghi prodotti da impianti di depurazione di reflui urbani: Quadro conoscitivo ed aspetti specifici. Rapporto n° 80/2008 http://www.isprambiente.gov.it/it/pubblicazioni/rapporti/il-riutilizzo-delle-acque-e-dei-fanghi-prodotti-da

several successful reuse activities operating since a few years in small communities of Southern Italy inland areas, will certainly be obliged to face problems difficult to cope with. (Articles 11 and 12). Finally, Italian National Standards for water reuse are presented in Ministerial Decree nr 152 of May 2006 which regulates the use of wastewater[227].

Other practitioners, however, positively evaluate the existing approach: by referring to only one class of microbiological quality, irrespective of the final use of recycled water, it facilitates monitoring and controls, as there is no need of differentiated controls based on the destination of recycled water, and it guarantees hygienic safety anyway[228].

Besides water availability levels in Italian regions, there are social and economic elements promoting or constraining water reuse practices in Italy, and in particular[229]:

- Density of population and productive activities: a higher density generally allows for a larger size of treatment plants, thus simplifying water reuse;
- Fragmentation of infrastructure management: the presence of many small treatment plants, managed by different entities (municipalities, treatment companies) makes it more difficult to organize water reuse in a coherent and cost-efficient way –and of water treatment in general;
- Discharges at sea: in some regions, long pipes discharging wastewater into the sea, often after primary treatment only, are very common (e.g. Ligurian sea and North-East Adriatic sea). In these cases, developing a water reuse system would require a larger technical and financial investment to upgrade existing infrastructures; and
- Peak touristic season: especially in coastal areas, during peak season tourists dramatically increase water demand, as well as wastewater production. In these areas, and especially in Southern Italy, water reuse could provide an additional water source and thus a greater flexibility of the water provision system.

The costs of water reuse include different elements, e.g. refinement of treated water to required quality levels, management of the distribution network. These costs are influenced by different factors (e.g. treatment types, size of the recycling plant), but it is still possible to provide some indicative average values.

Average costs, as calculated by ISPRA in a survey of several Italian recycling plants (different plants for different uses: urban, industrial, agriculture) range between 0.083 and 0.48 EUR/m^3. As a comparison, the costs of abstracting water from rivers and groundwater bodies is estimated at 0.015-0.2 EUR/m^3. High cost of recycled water is generally indicated as one of the main barriers to water reuse. As also noted by other authors (see above), ISPRA highlights that the technical and economic investments necessary to water reuse activities can only be justified for large plants[230].

Furthermore, at present it is not clear how additional costs of water reuse should be shared among the relevant stakeholders, especially because there are many of them (entities managing wastewater collection networks and treatment plants, entities managing distribution networks, irrigation consortia, provincial and municipal administrations, Regions, private firms, etc.). In particular, the role of ATOs (Autorità d'Ambito, managing authority of water and wastewater services) is not clear, in particular in light of the expected impact of water reuse on setting water prices for all uses from both reused and conventional water sources[231].

According to ISPRA, in light of high costs of upgrading existing water treatment plants for recycling effluents, it is unlikely that direct water reuse will be widely applied in the country, with the exception of those areas

[227] TYPSA, 2013
[228] APAT, 2008
[229] APAT, 2008
[230] ISPRA, 2009. L'ottimizzazione del servizio di scarico urbane: massimissazione dei recuperi di risorsa (acque e fanghi) e riduzione dei consumi energetici. Rapporto 93/2009. http://www.isprambiente.gov.it/it/pubblicazioni/rapporti/l2019ottimizzazione-del-servizio-di-depurazione
[231] ISPRA, 2009

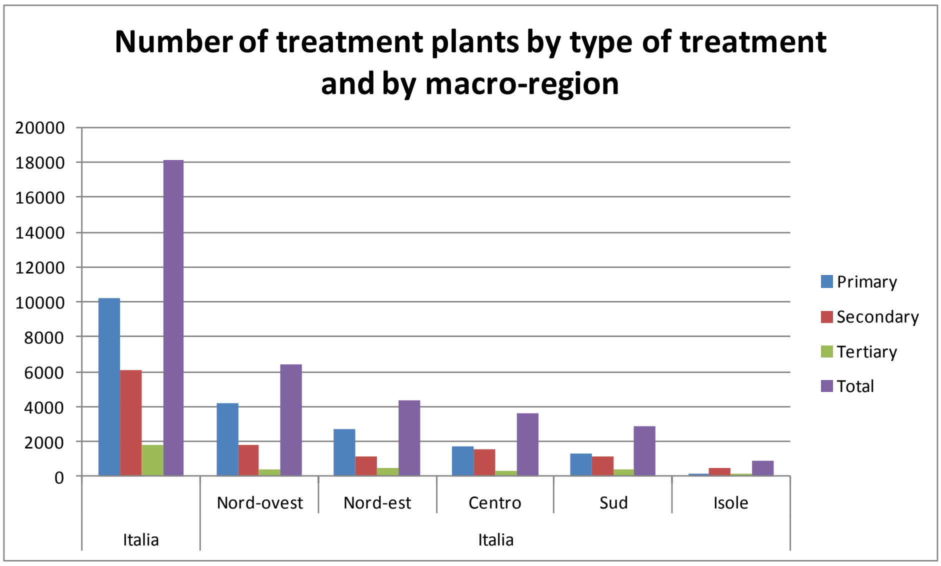
where the costs of abstracting freshwater is already very high (for geographical and climatic reasons) –and against which water reuse becomes convenient and thus competitive[232].

4.2 Wastewater collection and treatment

Wastewater treatment

The figure below presents the number of treatment plants and their treatment levels in 2012.

Figure 4.1 Number of treatment plants: by treatment type and total, by macro-region and total for the country



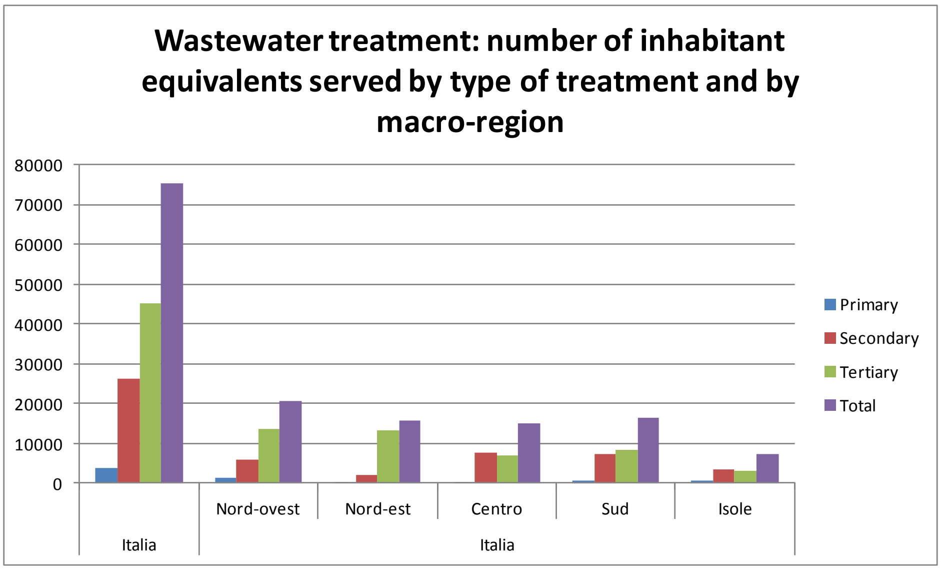
Source: ISTAT[233]

The figure below presents the number of inhabitant equivalent served by existing treatment plants in 2012.

[232] ISPRA, 2009

[233] http://dati.istat.it/Index.aspx?DataSetCode=DCCV_IMPDEP

Figure 4.2 Number of inhabitant equivalent served by existing treatment plants: by treatment type and total, by macro-region and total for the country (thousands inhabitants)



Source: ISTAT[234]

Current standards for water reuse

This section describes the current existing standards for water reuse in Italy.

Origin: treated urban and industrial wastewater

Potential uses and restrictions: Quality requirements are defined for 3 use categories: Agriculture, Non-potable urban uses, Industrial uses

Approach: Numerical limit values related to the bacteriological and physico-chemical water quality. Same values for the 3 use categories.

Parameters: 55 parameters must be measured. For parameters such as pH, ammonia nitrogen, specific electrical conductivity, aluminium, iron, manganese, chloride and sulphate concentrations, regional authorities may set limit values other than those mentioned in the Decree (after validation from the Ministry of Environment and the authorities in charge of the Protection of Natural Resources)[235].

The parameters stated in the Italian legislation are presented in Table 4.1.[236]

Table 4.1 Parameters for water reuse in Italy

Parameter	Threshold (max value)	Parameter	Threshold (max value)
pH	6-9.5	Tl – mg/l	0.001
SAR	10	V – mg/l	0.1
Gross materials	None	Zn – mg/l	0.5
Total Suspended Solids (TSS) – mg/l	10	Total cyanides – mg/l	0.05
BOD5 – mg O_2/l	20	Solphurs – mgH_2S/l	0.5
COD – mg O_2/l	100	Active Cl – mg/l	0.2
P tot – mg P/l	2	Clorures – mgCl/l	250

234 http://dati.istat.it/Index.aspx?DataSetCode=DCCV_IMPDEP
235 BIO by Deloitte, 2015
236 http://gazzette.comune.jesi.an.it/2003/169/2.htm

Parameter	Threshold (max value)	Parameter	Threshold (max value)
N tot – mg N/l	15	Fluorures – mgF/l	1.5
NH_4 – mg NH_4/l	2	Animal/vegetal fats and oils – mg/l	10
Electric conductivity µS/cm	3000	Mineral oils – mg/l	0.05
Al – mg/l	1	Total fenols – mg/l	0.1
As – mg/l	0.02	Pentaclorophenol – mg/l	0.003
Ba – mg/l	10	Total aldeids – mg/l	0.5
Be – mg/l	0.1	Tetracloroetilene, tricloroetilene – mg/l	0.01
Cd – mg/l	0.005	Chlorinates solvents – mg/l	0.04
Co – mg/l	0.05	Trialomethanes – mg/l	0.03
Cr tot – mg/l	0.1	Benzene – mg/l	0.001
Cr VI – mg/l	0.005	Benzo(a)pirene – mg/l	0.00001
Fe – mg/l	2	Nitric organic solvents – mg/l	0.01
Mn – mg/l	0.2	Total tensioactives – mg/l	0.5
Hg – mg/l	0.001	Chlorinated pesticides – mg/l (each)	0.00001
Ni – mg/l	0.2	Phosphorous pesticides – mg/l (each)	0.00001
Pb – mg/l	0.1	Other pesticides – mg/l	0.°05
Cu – mg/l	1	Escherichia coli UFC/100 ml	10 (80% of samples) 100 maximum point value
Se – mg/l	0.01	Salmonella	None
Sn – mg/l	3		

Monitoring: The distribution network owner is responsible for the monitoring of chemical and microbiological parameters, environmental and agronomical impacts, and impacts on soil. He shall send monitoring results to the regional authorities every year. A Control & Monitoring Plan to be implemented by the WWTP operator is set out in the discharge permit; this plan shall be proposed by the WWTP manager and agreed by the competent authority.

Application controls: The treated waste water distribution network shall be separated from the drinking water supply network and constructed so as to avoid cross contamination. Reclaimed water delivery points shall be marked and clearly distinguishable from those of water intended for human consumption.

Permitting system: Under this regulation, an authorization is required for discharging treated wastewater intended for reuse[237].

4.3 Agricultural irrigation: baseline

Agricultural sector profile

According to LUCAS, the profile of land use in Italy was as follows in 2012:

- Agriculture 51,38%;
- Forestry 16,74%;

[237] BIO by Deloitte, 2015

- Hunting and fisheries 0,48%;
- Uses with heavy environmental impact 4,50%;
- Services and residential use 11,03%; and
- No visible use 15,88%.

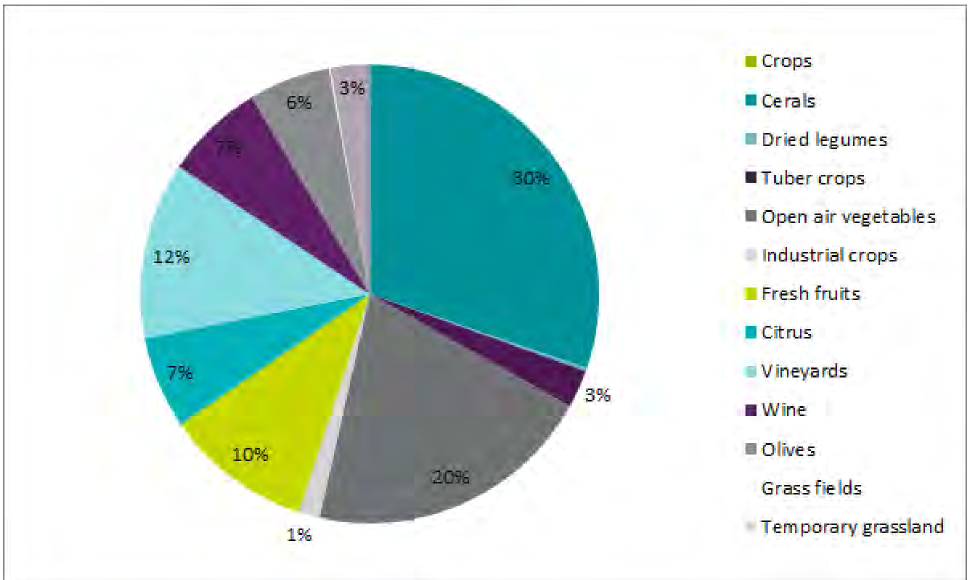
The land cover is as follows:

- Artificial 7,26%;
- Cropland 33,29%;
- Woodland 33,16%;
- Shrubland 5,20%;
- Grassland 16,27%;
- Bareland 2,14%;
- Water 2,47%; and
- Wetland 0,21%.

The total utilized agricultural area (UAA) in Italy is 12.7 million hectares. In 2011, the sector accounted for 3.2% of the total workforce. With respect to total employment in the period 2008-2011, trend in the agricultural sector show a higher volatility and, more in general, it does not follow the general national employment trend (Eurostat data).

In 2011, Italian agriculture produced around 60 Million tons of agricultural products. Figure 4.3 illustrates the share of total production by crop.

Figure 4.3 Total production by type of crops in 2011



Source: ISTAT[238]

Agricultural irrigation

Irrigated areas are unevenly distributed across the country: 66% of irrigated area is in fact concentrated in the relatively water-abundant North, whereas the rest is shared between the Centre (6%) and the South

[238] http://dati.istat.it/Index.aspx?DataSetCode=DCSP_COLTIVAZ&Lang=

(28%). The three major irrigated crops are maize, rice and vegetables (ISTAT, 2010). Irrigation is a strategic input in Italian agriculture. Although the irrigated agricultural area only accounts for 19% of the total Used Agricultural Area (UAA)[239] , in terms of production, irrigated agriculture accounts in fact for 50% of total production and 60% of total value added of the agricultural sector, and its products constitute the 80% of agricultural exports[240].

Water reuse for irrigation

The use of untreated wastewater has been practiced in Italy at least since the beginning of this century, especially on the outskirts of small towns and near Milan. Among the oldest cases of irrigation with wastewater is the "Marcite" where water from the Vettabia river, which receives most of the industrial and urban untreated wastewater, is used. Nowadays, treated wastewater is used mainly for agricultural irrigation covering over 4,000 ha. However, the controlled reuse of municipal wastewater in agriculture is not yet developed in most Italian regions because of a stringent normative which ignores the findings of recent research work and experiences of uncontrolled reuse so common in Southern Italy. One of the largest projects was implemented in Emilia Romagna where over 450,000 m3 /yr of treated effluents are used for irrigation of more than 250 ha. The real costs for the distribution of recycled wastewater (power, labor, network maintenance) are covered by the users. New wastewater reuse systems have been recentely completed in Sicily and Sardinia for agricultural irrigation[241].

In terms of infrastructures, existing irrigation systems are not homogeneous, and infrastructures are inadequate to operate and manage complex recycling systems. The costs of upgrading the distribution networks and irrigation systems to meet legal requirements would be huge. In addition, the fragmentation of infrastructures management poses further constraints[242].

4.4 Agricultural irrigation: proposal

Comparison of proposed draft JRC quality standards and standards applied in Italy

Draft JRC quality standards:

- Different standards for different categories of use of recycled water; and
- Four parameters to be measured.

National standards:

- Very stringent quality standards (and very detailed) not differentiated per type of use –i.e. all recycled water for all type of uses might comply with the same high standards; and
- A total 55 parameters to be measured.

Table 4.2 compares the limit values in the Italian and the draft JRC proposal only for the four parameters included in the proposed EU legislation. The BOD threshold in the Italian regulation is higher than the threshold included in the proposed EU regulation for category A. However, in general Italian thresholds are more stringent (or equivalent) than the thresholds included in the draft JRC proposal.

[239] ISTAT, 2010. VI Censimento generale dell'agricoltura. http://censimentoagricoltura.istat.it/inbreve/?lang=it
[240] Althesys, 2013. Le politiche di gestione dell'acqua in agricoltura. Synthesis report.
[241] Kamizoulis, G., Bahri, A., Brissaud, F., Angelakis, A.N., 2003. Wastewater recycling and reuse practices in Mediterranean Region: Recommended Guidelines. http://www.a-angelakis.gr/files/pubrep/recycling_med.pdf
[242] http://dspace.inea.it/bitstream/inea/529/7/1_Riutilizzo_irriguo_Dodaro.pdf

Table 4.2 Comparison of the draft JRC proposal and the national Italian standards

Reclaimed water quality category	*E. coli* (CFU/100 ml)		Total Suspended Solids (TSS) (mg/l)		Biochemical Oxygen Demand (BOD_5) (mg/l)		Turbidity (NTU)	
	Italy	EU - Maximum	Italy	EU - Maximum	Italy	EU - Maximum	Italy	EU - Maximum
A: Very High quality	10 (80% of samples)	100	10	10	20	10	Not measured	5
B: High quality	10 (80% of samples)	1,000	10	25	20	20	Not measured	-
C: Good quality	10 (80% of samples)	10,000	10	35	20	25	Not measured	-
D: Medium quality	10 (80% of samples)	-	10	35	20	25	Not measured	-

Overall, **the Italian regulation is much more stringent** than the draft JRC proposal.

Non-binding standards for water reuse

In light of the fact that the national regulation is much stricter than the draft JRC proposal, it can be considered that the Italian regulation will not change in the presence of non-binding standards for water reuse at the EU level. For this reason, no impact can be expected from the introduction of such standards – and the IA exercise was thus not conducted.

Legally binding standards for water reuse

In presence of legally binding standards for water reuse at the EU level, two scenarios could occur:

- Italy will not adjust to the EU standards (perhaps with the exception of the BOD parameter, which might be lowered to the EU standards for category A). In fact, decision makers might still prefer to keep the existing regulations, as it is more stringent than the draft JRC proposal; and
- The national legislation and regulation are changed, so that the EU standards are fully adopted and implemented in the country.

In the first case, no relevant impacts can be expected. Thus, for the sake of the IA exercise –and to compare two different situations- it is assumed that Italian legislation and regulation will be fully adjusted to the legally binding EU standards.

4.5 Agricultural irrigation: impact assessment

Non-binding standards for water reuse

The impact assessment was not carried out (see above).

Legally binding standards for water reuse

Economic impacts	
Functioning of the internal market and competition	With the current regulation, water recycling is only viable for large wastewater treatment plant. With the onset of EU standards, much less stringent than existing ones, water recycling might become viable for all existing treatment plants (both municipal and private plants), or at least for a larger share of existing operators. Thus, this policy options would help in widening the access to water reuse technologies and practices and promote their adoption.

Economic impacts	
Operating costs and conduct of business/Small and Medium Enterprises	Currently, the costs of adjusting existing treatment plants to comply with water reuse legislation are very high, and this is linked to the very stringent quality standards which must be attained. The introduction of the draft JRC proposal is likely to reduce the costs of adapting current wastewater treatment plants to water reuse practices
Administrative burdens on businesses	As compared to the current situation, the introduction of the draft JRC proposal would reduce the costs currently borne by wastewater treatment operators, and in particular: (i) the costs of applying for a water reuse licence; (ii) monitoring and reporting costs: only four parameters should be monitored and reported, against the 55 parameters that must be monitored at present. On the other hand, the definition of four quality categories (depending on the final use of recycled water) might slightly complicate the application procedure, as the final use of recycled water should be well documented.
Public authorities	The costs of completely changing the existing legislation and regulation on water recycling could be significant, as significant might be the costs of adjusting the current enforcement and governance structure to the new parameters. This would occur, in particular, because of the switch between the current system (with no quality categories) and the draft JRC proposal, which distinguish four quality categories depending on the final use of water. On the other hand, the administrative costs of enforcement and compliance checking are expected to decrease: in fact, only four parameters should be checked and reported against the 55 parameters currently monitored; as a consequence, authorities in charge of enforcement and control should only check 4 parameters at once –thus the overall control procedure should be much faster.
Innovation and research	The introduction of the draft JRC proposal for water reuse would definitely promote the uptake of water reuse technologies and practices, as it would remove some of the current barriers linked to a too stringent regulation. Smaller municipal and private plants might also be able to adopt water reuse practices, and this might promote research and innovation.
Consumers and households	A wider adoption of water recycling technologies might imply increased costs for water users. Additional costs might be charged on farmers: however, an increase in irrigation water price might provide a negative incentive to the use of recycled water in irrigation. Alternatively, as it often happens, additional costs might recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with available data and information.

Social impacts	
Employment and labour markets	A wider adoption of water reuse practices might create new jobs in the sector. However, it is not possible to estimate the potential magnitude of this impact.
Governance, participation, good administration, access to justice, media and ethics	Adjusting national standards to the draft JRC proposal might have a positive impact on the public perception of using recycled water for irrigation, as it might serve as a further guarantee of the overall safety of the system even though the quality requirements are less strict than they are now. In addition, only a few (four) parameters must be measured and reported, and this can facilitate the communication to common citizens, as well as their understanding of water quality information –at present, only a specialist can go through the 55 quality parameters and fully understand what their mean in terms of quality.
Public health and safety	The draft JRC proposal includes much less stringent quality requirements as compared to the current national regulation. Adjusting to EU standards will inevitably result in a lower quality of water reused in irrigation. However, the proposed EU standards were developed to protect the health of EU citizens, so negative health impacts can be hardly expected.

Environmental impacts	
Water quality and resources	A wider adoption of water reuse technologies can only be encouraged in a country affected by water over-abstraction issues, and in particular in some cases: (i) water-scarce regions; (ii) coastal areas during touristic seasonal peak. In some regions, and especially in the South, seasonal water scarcity often threatens domestic water supply, which is normally given priority over agricultural irrigation. Water recycling for irrigation would reduce the need for freshwater abstraction, and it would release the pressures on domestic water supply during scarcity periods. The same can be said for coastal areas during the touristic seasonal peak; in addition, it must be noted that the peak is usually in summer, which is the driest season if the year.
Renewable or non-renewable resources	In water-scarce regions, a large adoption of water recycling might cause the expansion of irrigated agriculture, which is now constrained by water availability (hypothetic impact – to be verified).
The environmental consequences of firms and consumers	Irrigating crops with recycled water is in principle an environmental-friendly practice, as it spares freshwater resources which can be diverted to other uses (e.g. domestic) or to the environment.

4.6 Agricultural irrigation: Comparison of the alternative policy options

As previously illustrated:

- It is not expected that the introduction of EU non-legally binding standards will have an impact on the current national legislation –decision makers are likely to keep the existing regulation, way more stringent than the draft JRC proposal. In this case, no relevant impact can be expected; and
- In presence of legally binding standards for water reuse at the EU level, two scenarios could occur: (i) Italy will not adjust to EU standards; or (ii) the national legislation is adjusted to the proposed EU regulation, which is thus fully adopted and implemented. The IA was conducted assuming that the second scenario will occur.

Table 4.3 Synthesis table of impact assessment for agriculture irrigation

	Non-binding standards for water reuse	Binding standards for water reuse
Overall economic impact	0	+
Operating costs and conduct of business/Small and Medium Enterprises	0	++
Administrative burdens on businesses	0	+
Public authorities	0	-
Innovation and research	0	+ +
Consumers and households	0	0/-
Overall social impact	0	+
Employment and labour markets	0	+
Governance, participation, good administration, access to justice, media and ethics	0	+
Public health and safety	0	0
Overall environmental impact	0	++
Water quality and resources	0	++
Renewable or non-renewable resources	0	0/+
The environmental consequences of firms and consumers	0	++

++ Significant positive impact **- -** Significant negative impact **0** No relevant impact

+ Mild positive impact **-** Mild negative impact

4.7 Aquifer recharge: baseline

Groundwater resources

Groundwater makes up for almost 50% of water abstracted for domestic water supplies[243]. **Overexploitation** has been reported in the North, in the lower reaches of the Po plain and around Venice, due to industrial and agricultural uses as well as gas and oil extraction. In some regions, the economic viability of farming is undermined by groundwater abstraction above recharge rates[244]. One of the main drivers of the over-abstraction of available resources by all sectors (domestic, industry and agriculture) is the high population density. The consequences of over-abstraction are widespread, and include water scarcity events, desertification risk in vulnerable areas and salty water intrusion in coastal areas[245]. Water availability differs significantly from Northern to Southern Italy. In the North, water is relatively abundant, due to stable and abundant flows in water courses throughout the year. In addition, out of 13 billion m^3 of groundwater available annually, over 70% is located in the North, and particularly in the Po river plain. In contrast, the South of Italy is often subject to long periods without precipitation, resulting in droughts and water rationing[246].

Over 52% of GWBs are assessed at good quantitative status, according to Italy's reporting; however, the status is unknown for almost 32% (see the table below). No information was reported for Sardinia and Sicily (codes: ITG, ITH). The breakdown by region is similar to that for the chemical status of GWBs. For groundwater bodies, almost 37% were assessed as being of good status in 2009, and the share is expected to rise to almost 55% in 2015 (See Table 4.4; these figures do not include ITG and ITH.) In the Po RBD (code: ITB), the share of GWBs of good status is expected to rise from 48% to 80%; in the Central Apennines RBD, from almost 25% to over 40%. Qualitative and quantitative status are illustrated in the tables below[247].

Table 4.4 Overview of the chemical and quantitative status of groundwater bodies in Italy

RBD	Total	Good		Poor		Unknown	
		No.	%	No.	%	No.	%
ITA	123	95	77.2	17	13.8	11	8.9
ITB	141	81	57.4	35	24.8	25	17.7
ITC	186	106	57	75	40.3	5	2.7
ITD	11	7	63.6	4	36.4	0	0
ITE	133	43	32.3	45	33.8	45	33.8
ITF	139	27	19.4	17	12.2	95	68.3
Total	*733*	*359*	*49*	*193*	*26.3*	*181*	*24.7*

Table 6.6: *Chemical status of groundwater bodies.*
Source: *WISE*

RBD	Total	Good		Poor		Unknown	
		No.	%	No.	%	No.	%
ITA	123	68	55.3	2	1.6	53	43.1
ITB	141	89	63.1	27	19.1	25	17.7
ITC	186	131	70.4	50	26.9	5	2.7
ITD	11	8	72.7	3	27.3	0	0
ITE	133	59	44.4	20	15	54	40.6
ITF	139	31	22.3	13	9.4	95	68.3
Total	*733*	*386*	*52.7*	*115*	*15.7*	*232*	*31.7*

Table 6.7: *Quantitative status of groundwater bodies.*
Source: *WISE*

Aquifer recharge

At present, artificial aquifer recharge interventions are not common in Italy, and current practices focuses mainly on pilot experimental sites (Regione Emilia Romagna, 2008[248]; confirmed by other sources up to 2015, some of them included in this template). Existing examples of artificial aquifer recharge are being implemented thanks to EU LIFE and FP7 funding:

- LIFE+ AQUOR (ended in May 15): implementation of artificial aquifer recharge in the Province of Vicenza - http://www.lifeaquor.org/en

[243] ISTAT, 2012. Giornata Mondiale dell'Acqua – le statistiche dell'ISTAT. Statistiche Focus, ISTAT. http://www.istat.it/it/archivio/57514
[244] OECD, 2013
[245] DGSRIS, 2007
[246] OECD, 2013
[247] EC, 2012. Italy, WFD Implementation Report - http://ec.europa.eu/environment/water/water-framework/pdf/3rd_report/CWD-2012-379_EN-Vol3_IT.pdf
[248] http://ambiente.regione.emilia-romagna.it/acque/informazioni/documenti/studio-sulla-ricarica-artificiale-delle-falde-in-emilia-romagna/view

- LIFE+ TRUST (ended in December 2011): research in the aquifer recharge area in the Veneto plain (rivers Isonzo, Tagliamento, Livenza, Piave, Brenta and Bacchiglione) http://www.lifetrust.it/cms/ ;
- LIFE+ WARBO (ended in March 2015): testing of artificial aquifer recharge methods (from rainwater) in the Po Delta and in the Pordenone province - http://www.warbo-life.eu/it ; and
- MARSOL – FP7 (on-going): Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought – Pilot sites in Italy: Brenta (Veneto) and Serchio (Liguria) - http://www.marsol.eu/6-0-Home.html .

The WFD was transposed in the Italian legislation with the Legislative Decree 152/06 (Environmental Act). Artificial aquifer recharge, in particular, is included in Annex 11 and it is considered as a supplementary measure to be adopted in water management to achieve WFD quality objectives.

A recent modification to the Environmental Act –Art. 24, comma 1, Law 97/2013- clarified some important technical and permitting aspects of aquifer recharge. In particular, these interventions can be authorized provided that they are executed in compliance with the criteria to be established by the Ministry of Environment through a specific Decree –currently under preparation.

According to the Legislative Decree 152/06, the discharge in groundwater bodies is forbidden with some exceptions; such exceptions include artificial aquifer recharge, provided that his does not compromise the achievement of the environmental objectives established for the specific groundwater body. Aquifer recharge is established and regulated by the RBMPs and the Water Protection plan.

Artificial aquifer recharge is also subject to Environmental Impact Assessment[249].

Artificial aquifer recharge was also included in the National Operational Programme "Governance and systemic actions – European Social Fund 2007-2013 – Axis E Institutional Capacity, Specific Objective 5.5 Reinforce and Integrate the environmental governance system, Action 7A Horizontal actions for environmental integration", as part of models and tools for water resource management (natural water retention measures, aquifer recharge and participatory systems)[250].

At present, no testing of artificial groundwater recharge with treated effluents has been reported: this practice is neither forbidden nor regulated, and it has never occurred so far in the country.

4.8 Aquifer recharge: proposal

Given the current status of artificial aquifer recharge in the country, the development of EU standards (both binding and non-binding) is likely to promote the practice in the country. In order to differentiate the two policy options and conduct an informative impact assessment exercise, two hypotheses were made:

- The development of non-binding standards for water reuse might promote research and pilot testing of aquifer recharge with treated effluents. It is assumed that non-binding EU standards will not be transposed in the national legislation (at least in the short-medium term), so that the practice will only be applied at the research/experimental level –in this way, this policy option and its impacts can be differentiated from the second option (legally binding standards); and
- Legally binding standards will be transposed in the national legislation, so that artificial aquifer recharge with treated effluent will become an established and regulated practice in the country. After legal adoption, it can be expected that this practice will only be adopted at a pilot testing level for a few years, and that it will become common practice only afterwards. In any case, at the current level of knowledge, it is not possible to forecast to what extent this practice will be implemented in the national territory. Given the low water availability in Southern regions, artificial groundwater recharge with treated effluent seems to be a promising practice; however,

249 LIFE AQUOR, 2015. La ricarica delle falde in condizioni controllate – Linee guida tecnico-operative. http://www.lifeaquor.it/file/649-A6_linee_guida_tecnico_operative_I.pdf

250 http://www.pongas.minambiente.it/pubblicazioni/misura-7a/pubblicazioni/news/studio-di-settore-modelli-e-strumenti-di-gestione-e-conservazione-delle-risorse-idriche-sistemi-naturali-di-ritenzione-idrica-ricarica-artificiale-delle-falde-e-processi-partecipativi

uncertainties exist about its costs and who will sustain these costs (and who will invest in aquifer recharge with treated effluents).

4.9 Aquifer recharge: impact assessment

The assessment of impacts for both options is presented in the table below.

Economic impacts	Non-binding standards	Legally binding standards
Operating costs and conduct of business/Small and Medium Enterprises	This option is expected to promote aquifer recharge with treated effluent only at the experimental level. It can be expected that research and pilot testing will be conducted by public institutions with the participation of private institutions financed by public funding (e.g. LIFE, Horizon 2020 funding as it is happening today, national funds). So no relevant impact can be expected on operating costs and conduct of private businesses –but it is rather to bring about new research and funding opportunities.	At present, aquifer recharge with treated effluents does not exist in the country. Additional transaction and compliance costs can be expected in those situations where a practice already exists, and a new regulation imposes for example stricter standards, or more complex permitting/control procedures. This would not be the case of aquifer recharge with treated wastewater in Italy. Of course, the introduction of this practice will involve significant investments for those entities wanting to engage in this practice, but this will be voluntary –and it will bring significant benefits for different stakeholders, for example in terms of increased water availability. In addition, at present it is not possible to forecast who will bear the investment costs –it might as well be that public authorities (e.g. regional authorities, in charge of water management; EU funding) will invest in this practice as it can be beneficial for society at large. However, in terms of operating costs for businesses, no relevant impact is expected.
Administrative burdens on businesses	Under this option, aquifer recharge with treated effluents is expected to be applied only at the pilot testing/ research level, so no additional administrative burdens on businesses can be expected. The option is rather to bring about new research and funding opportunities.	In case the Italian legislation will change to include aquifer recharge with treated wastewater, companies wanting to adopt this practice will of course have legal obligations to fulfil (e.g. application for permits), but these additional costs will be compensated by revenues from the new practice as well as benefits for the society as a whole.
Public authorities	This option is mainly expected to promote research on aquifer recharge with treated effluents, so no additional burden for public authorities can be expected. Public authorities can decide to invest in research and pilot projects, but this will be a voluntary budget allocation decision (potentially compensated by the benefits of new knowledge) and cannot be considered as a negative impact.	Transposing the EU standards into national legislation will imply additional costs for the national administration, and in particular: (i) costs of developing the new law (background studies, legislative process including impact assessment); (ii) costs of adjusting the administrative system to implement the law (receiving and processing application, control of quality requirements, etc.).
Innovation and research	This option is expected to significantly promote research and innovation in aquifer recharge with treated effluents.	This option is expected to significantly promote research and innovation in aquifer recharge with treated effluents.
Consumers and households	This option is mainly expected to promote research on aquifer recharge with treated effluents, so no relevant impact on consumers and households can be expected.	Once this practice is adopted, the costs of recharging aquifers might be reflected in water users' bills. However, at present is not possible to say something more specific about the expected impacts on water bills, especially because it is not possible to forecast who will bear the costs of aquifer recharge with treated effluents, and how these costs will be recovered (different entities can be involved, and different financing and cost-recovery schemes could be applied).

Social impacts	Non-binding standards	Legally binding standards
Employment and labour markets	The promotion of research and innovation on treatment technologies for aquifer recharge might increase the demand for qualified technical and scientific personnel. Background studies on the introduction of this technology in Italy might involve contributions from private consultancies or national universities and research institutes. However, it is very difficult to infer something more than qualitative about the possible impact on the labour market. It can reasonably be expected that water recycling for aquifer recharge will be a niche sector, so the macro-economic impact will be very limited (both in case of research and development of the topic that in case of future adoption of this practice).	This option might: Increase the demand for qualified personnel in research and pilot testing of aquifer recharge techniques with treated effluents; and Once the practice is regulated and established in the country, additional jobs will be created in the sector. However, it is very difficult to infer something more than qualitative about the possible impact on the labour market. It can reasonably be expected that water recycling for aquifer recharge will be a niche sector, so the macro-economic impact will be very limited (both in case of research and development of the topic that in case of future adoption of this practice).
Governance, participation, good administration, access to justice, media and ethics	The development of EU standards, as well as the consequent promotion of research and innovation in the country, might bring the practice to the attention of the public. In addition, the existence of EU standards could positively steer public perception and acceptance of this practice.	The adoption of common EU standards would protect water users, who are then supposed to be better informed about the quality of the water they use. In addition, the existence of EU standards could positively steer public perception and acceptance of this practice.
Public health and safety	Research and pilot testing might improve existing technologies, also in terms of safety and thus public health.	Research and pilot testing might improve existing technologies, also in terms of safety and thus public health. Once the EU regulation is adopted in the country, quality standards are expected to protect public health.

Environmental impacts	Non-binding standards	Legally binding standards
Water quality and resources	This option is expected to promote research and pilot testing, so some quantitative improvements of groundwater bodies can only be expected at the local level.	The diffusion of aquifer recharge with treated effluents techniques can significantly contribute to current qualitative and overexploitation issues affecting groundwater bodies –and this is especially true in Southern regions. However, at the moment it is not possible to infer an estimate of the level of uptake of this practice across the national territory, so it is not possible to provide an indication of the magnitude of the positive impact on groundwater resources –the larger the uptake, the larger the positive impact.
Renewable or non renewable resources	Groundwater only – please see above.	Groundwater only – please see above.
The environmental consequences of firms and consumers	No relevant impact is expected.	The adoption of aquifer recharge with treated effluents will contribute to increasing the sustainability of the water use system in the country.

4.10 Aquifer recharge: Comparison of the alternative policy options

As previously illustrated:

- Non-binding standards are expected to have a positive impact on research and pilot testing, and thus on developing knowledge on aquifer recharge with treated effluents –with a consequent positive impacts on research and innovation; and
- Legally binding standards are expected to be transposed into national legislation, contributing to the uptake of this practice in the country. Overall, this option is expected to have a positive impact on research and innovation, job creation, available water resources among others.

Table 4.5 Synthesis table of impact assessment for aquifer recharge

	Non-binding standards for water reuse	Binding standards for water reuse
Overall economic impact	**+**	**0/+**
Operating costs and conduct of business/Small and Medium Enterprises	0/+	0/+
Administrative burdens on businesses	0/+	0/+
Public authorities	0	-
Innovation and research	+ +	+ +
Consumers and households	0	0/-
Overall social impact	**+**	**+**
Employment and labour markets	+	+
Governance, participation, good administration, access to justice, media and ethics	+	+ +
Public health and safety	0/+	+
Overall environmental impact	**0/+**	**+**
Water quality and resources	+	+ +
Renewable or non renewable resources	0	0
The environmental consequences of firms and consumers	0	+

++ Significant positive impact
- - Significant negative impact
0 No relevant impact
+ Mild positive impact
- Mild negative impact

5. Spain

5.1 Spain: tackling water security in a wider sense

Despite common wisdom and severe water stress in many areas of the country, reclaimed wastewater reuse in Spain is relevant for many dimensions of water security, and not just to manage the risk of shortages (including droughts). Water reuse mainly contributes to addressing inadequate quality and also to control the undermining of resilience of freshwater systems overall.

Overview of water use

The spatiotemporal rainfall and runoff variability, particularly pronounced in some areas of the country (such as south and south-eastern Spain or island regions), shapes the particularities of the Spanish Mediterranean basins in terms of water resources availability and distribution (van Loon and van Lanen, 2015; Versini et al. 2016). Mediterranean rivers have large periodic floods, transporting significant amounts of sediments, shaping braided channels, while many streams are intermittent or ephemeral (Lobera et al., 2016). Overall, these rainfall and runoff patterns concur with the intensive use of water resources, mostly in agriculture but also due to tourism inflows, in some cases due to a quite complex system of dams and reservoirs, part of which have induced significant hydromorphological alterations (González del Tánago et al., 2015). Downstream reaches are commonly deprived of high flows, which carry sediments, modify channel morphology, and maintain habitat complexity.

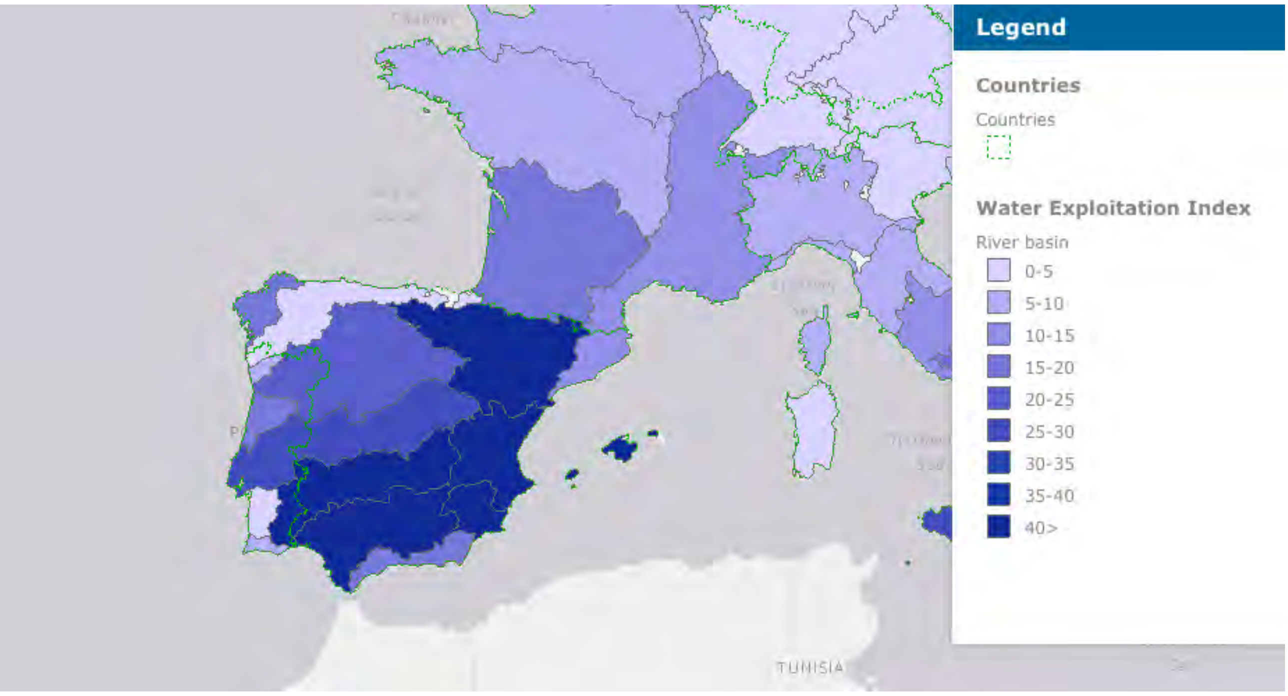
Given the limited decoupling between water use and economic growth trends, growing water demand has led to increasing water scarcity and related drought risk (Vorösmarty et al., 2000). In some cases, this is also the result of the lack of coordination of several sectoral policies, which has led, for instance, to oversized infrastructures and increasingly idle facilities (including desalination plants) (March and Saurí, 2014). Additionally, it is common to find flawed enforcement (and inadequate structure) of water use rights, mostly regarding groundwater resources, and over-allocation of surface water use rights, leading to potential overexploitation (Libecap, 2015; Esteban and Dinar, 2016).

The fact that drought events are becoming more frequent in the Spanish Mediterranean basins (Garrido et al., 2012), where the average annual demand of water is already higher than the long-term renewable resources, has led to an increased uncertainty about water security, something that is exacerbated by climate change. These critical issues call for improved adaptation mechanisms and strengthened resilience, both in terms of demand reduction and increase on the supply side (including through reclaimed wastewater reuse). Therefore, the use of alternative (non-conventional) sources of water has been increasingly considered within RBMPs in Spain as a contribution to water security (i.e. to mitigate quality concerns and as a measure for efficient water allocation and use) in accordance with the CIS Guidelines (EC, 2016).

In Spain, gross freshwater abstraction by sector during the period 2000-2010 (OECD, 2015) shows that irrigation accounts for 63% of all water withdrawal; water cooling for power generation for 19%; 16% for public water supply; and 2% for the manufacturing industry. Around 20% of the total annual water was abstracted (2010) from groundwater sources (6,595 hm3) and 80%, from surface sources (26,949 hm3). Gross water abstraction declined by 8% during the period 2000-2010, but groundwater abstraction has increased by 10% in the same period. These trends remain mostly stable since then.

Fig 5.1 shows the geographical layout of the Water Exploitation Index (WEI) at river basin scale during the dry season of 2012, with the highest index overlapping the driest areas – southern and eastern Spain. These river basins typically hit high values in the index throughout the year.

Figure 5.1 Water exploitation index at river basin scale, summer 2012



Source : EEA[251]

Dissociating water reuse from purely quantitative management

As a result of low and variable rainfall (2/3 of the country suffer from infrequent rainfall – OECD, 2015), water has always been a limiting factor for Spanish economic development. Yet, Spain has been able to harness the potential of water mostly for agricultural development, hydropower generation, tourism, and urban development. Nevertheless, the Spanish economy, specifically in its most competitive areas, which have proved a high level of resilience to the current world economic crisis, such as tourism and agriculture, are heavily dependent on water availability.

As in other medium-high water-stressed areas in the world (abstracting around 30% of its total available renewable resources – ibid., 2015), freshwater resources in Spain are intensively used, mostly in the most water scarce regions (i.e. southeastern Spain) where population, visitors and the most water intensive activities tend to concentrate: i.e. 70% of annual visitors (68.1m tourists in 2015 – INE, 2016) go to the Mediterranean regions, the Atlantic coast of Andalusia and the archipelagos – this mostly happens between May and September. This has resulted in water withdrawal rates and wastewater discharges that are already in excess over the capacity of natural sources and the infrastructures to meet current demand even in the absence of drought. Available evidence about climate change shows that long-term water availability will decrease in the near future (Eliott et al., 2014).

Furthermore, water security is no longer related only to water availability, but also to water quality concerns and environmental sustainability. It refers to the ability to ensure the good functioning of the water cycle as a whole, to allow for the perennial use of water for water-reliant activities and specifically the production of food and services associated to the good health of aquatic ecosystems (López-Gunn et al., 2016).

Quantitative water management is related to quality objectives through the establishment of ecologic flows in many rivers, although these flows are generally not clearly related to the achievement of a good ecological status. Ensuring that the established e-flows guarantee a good ecological status is one of the recommendations from the EC in the WFD 4th implementation report (EC, 2015)

While traditional strategies to alleviate scarcity were focused on augmenting supply through dams and canals – thus explaining why Spain is one of the world's leaders in number of dams per million inhabitants, the country is also a pioneer in river basin planning, facing crop water security and climate variability

251 http://www.eea.europa.eu/data-and-maps/explore-interactive-maps/water-exploitation-index-for-river

concerns. As a result of that, Spanish RBMPs have been considering alternative water sources from the onset, with a prevailing standard regulating water reuse that was enacted in 2007.

However, Spain has mostly dealt with structural water scarcity and increasingly frequent drought events through alternative water sources at higher marginal costs (from groundwater, with increased energy costs due to lower water tables, desalination of brackish water and seawater, and reclaimed wastewater reuse). Incentives have been in place to make these sources available but neither to conserve the water that makes them meaningful nor to make them work at full capacity (Gómez et al., 2013).

There is a remarkable contrast between financially cheap but increasingly scarce sources (i.e. groundwater) and expensive albeit abundant alternatives (i.e. desalinated water). Path dependency tends to favour the use of the former, thus reinforcing unsustainable trends. The latter (including reclaimed wastewater) is then used for emergency situations – the loss of economies of scale makes these sources financially less competitive.

Progress in the recovery of capital and operational costs is mostly limited to urban water services; in agriculture there is still a long way to go, where measures to ensure the recovery of environmental and resource costs are limited (EC, 2015). Besides, water prices are low if compared to the cost of marginal resources and there is much leeway for improvement in terms of accounting for resource (mainly that related with water scarcity), and environmental costs.

Some additional evidence shows that:

- According to Luo et al (2015) by 2040 the forecast of the Aqueduct Projected Country Water Stress Ranking for 2040 under a Business-as-Usual Scenario, Spain ranks 32 (out of 161): 4.07: all sectors; 3.64: industrial; 3.64: domestic and 4.22: agricultural, for a maximum value of 5.00);
- In 2012, the Water Exploitation Index was 33.6 (Eurostat, 2016);
- The percentage of years (MAGRAMA, 2014)) classified according to their average rainfall (period 1941-2013) is as follows: 2.7% extremely dry (R<495 mm) and 4.1% extremely wet (R>893 mm); 31.5 % very dry (495<R<555 mm) and dry (555<R<600 mm); 20.5% normal (600<R<664 mm); 41.1% wet (664<R<664 mm) and very wet (747<R<893 mm). When analysing the PNR (Percentage of Normal Rainfall [252]) during the period 1941-2014, it can be seen that ~55% of years (54,8%, during the period 1941-2013, MAGRAMA, 2014) registered an annual rainfall below the average (MAGRAMA, 2015);
- According to the Spanish System of Water Management [253], under the WFD and the Spanish National Plan for Water Quality: Sanitation and Wastewater Treatment (2007-2015), significant activity in wastewater treatment has been developed in Spain, with an investment over 10,000 M€, more than 2,950 wastewater treatment plants (WWTP) and a capacity of more than 4,000 hm^3/year of treated wastewater, even if this may be perceived as insufficient; and
- The volume of treated wastewater was estimated at 4,998 hm^3 in 2013 (INE, 2015)

Failures to meet set WFD objectives, particularly in relation to flows and quantitative status of water bodies

According to the available data from RBDs and RBMPs, and to the 4th WFD implementation report (EC, 2015):

- The ecological status of the 4,184 Natural Surface Water Bodies (NSWB) was as follows (% by number of NSWB): High, 10.1%; Good, 33.3%; Moderate, 29.0%; Poor: 6.9%; Bad, 3.3%; Unknown: 17.4%, According to their chemical status (% by number of NSWB), 56.8% was good; poor, 4.3%; unknown, 38.8%;

[252] The PNR (ratio, expressed in %, between accumulated rainfall during a year and the average annual rainfall for a place and period) is an indicator used to assess drought (MAGRAMA, 2014).

[253] Chapter 3.5: http://www.magrama.gob.es/es/agua/temas/sistema-espaniol-gestion-agua/

- The ecological potential of the 966 Artificial and heavily modified surface water bodies (AHMSWB) was as follows (% by number of AHMSWB): high, 0.2%; good, 32.0%; moderate, 29.0%; poor: 11.1%; bad, 8.0%; Unknown: 19.2%. By their chemical status (% by number of AHMSWB): good, 61.3%; Poor, 9.5%; Unknown, 29.2%;
- The number and % of surface water bodies affected by significant pressures (linked to flows and quantitative status of water bodies) were as follows: a) Water abstraction: 1,104 SWB affected; 21.4%; b) flow regulations and morphological alterations: 1,553 SWB affected; 30.4%; c) Other morphological alterations: 22 SWB affected; 0.4%;
- The chemical status of the 494 groundwater bodies (GWB) was as follows (% by number of GWB): Good, 66.0%; Poor, 32,9%; Unknown, 8%. By their quantitative status (%by number of GWB): Good, 71.3%; Poor, 27.3%; Unknown, 1.5%; and
- There are significant differences between RBDs. For instance, many of the RBDs in the Canary islands reported that all of their NSWB were in a Good chemical status, while some Mediterranean RBDs reported that all of theirs were in a Poor one; or northern and north-western RBDs reported that all of their GWB were in a Good quantitative status whereas some of the Canary islands RBDs reported that all of theirs were in a Poor one.

Water reuse potential

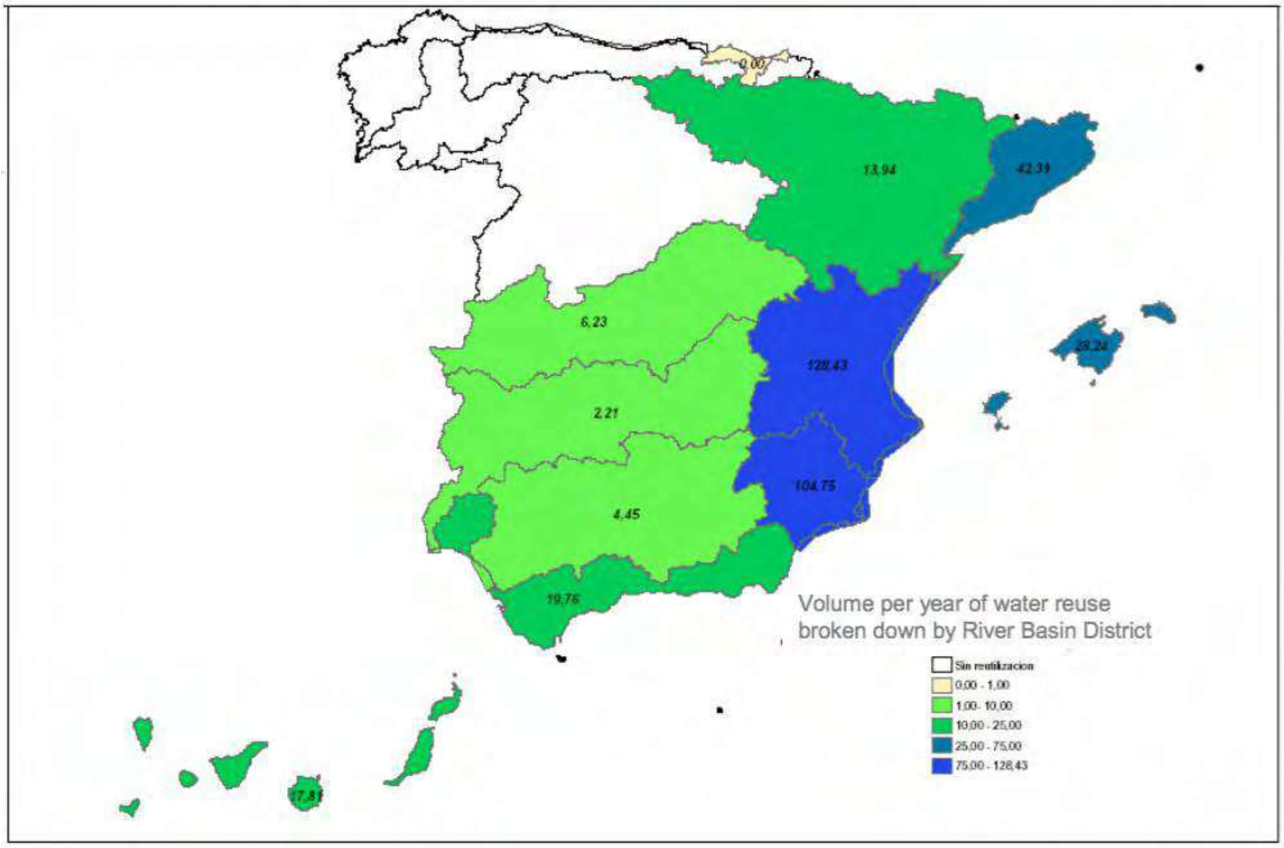
Current status

All of RBDs in Spain already consider water reuse in their RBMPs. Current data from the second cycle of RBMPs (all River Basin Districts included except Catalonia and Canary Islands, where the most updated data from the river basin authority have been used) shows that reclaimed water in Spain reached 413 hm^3/yr in 2013. Their estimations at the plan submission date approached 520 hm^3/yr for 2015 with extended projections in 2021. Should these projections and regional plans for water reuse – e.g. Madrid and Catalonia, be factored in, the total estimated volume would soar up to 1,150 hm^3/yr,[254] showing what is actually a potential upper bound if all planned investments are in fact implemented.

Mediterranean areas reported higher numbers, with maximum volumes at Júcar (29%), Segura and Mediterranean Andalusia (19% each) River Basin Districts, in SE Spain. This spatial distribution resembles the water exploitation index above.

[254] According to the draft National Plan for Water Reuse (MARM 2010a), which was not further developed and implemented as such

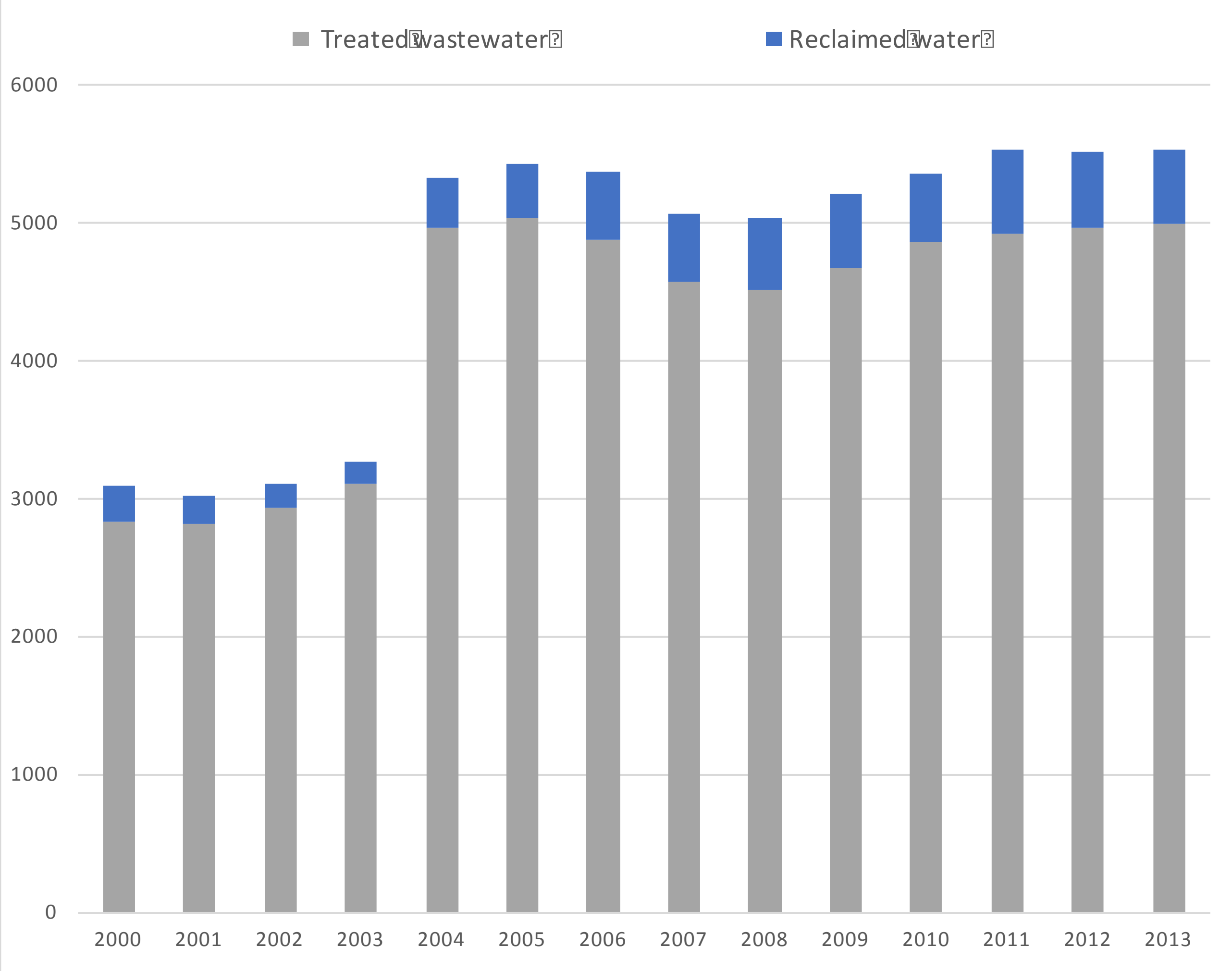
Figure 5.2 Reclaimed water by River Basin Districts (data from Reuse Database – CEDEX, 2007)



Source: Iglesias et al., 2010

Total volumes disclosed in the Survey of Water Supply and Sanitation, according to official data from the Office for National Statistics (INE, 2015a) differ from the RBMPs data, with a total volume of water reuse of 531 hm^3 *per annum* in 2013. Disparities may be due to differing criteria on the year used as a "current reference" within RBMPs. The total amount of reclaimed wastewater was 11% of the total volume of wastewater treated in 2013. This share remained steady (10-12%) from 2007, when the Spanish water reuse regulation came into force. Before 2007, the average value was lower than 8%. Again, the situation was especially remarkable in SE Spain (including Segura and Júcar River Basin Districts, plus the Balearic Islands), where 62%, 55% and 48% of wastewater treated was reused in 2013, respectively (INE, 2015a).

Figure 5.3 Trend in water reuse in Spain. Total annual volumes (hm³/yr) in series 2000-2013 (INE, 2015a)



Source: INE, 2015a

According to the Reuse Database working group (CEDEX – Iglesias, 2010), 71.0% of reclaimed water in 2007 was used for irrigation (261.37 hm³); 17.7% for environmental purposes, including aquifer recharge; 7.0% for recreational uses; 4.0% for urban uses and 0.3% for industrial uses. Updated data from official statistics, confirm a similar breakdown in 2013, with a 64.4% of the water reclaimed used for irrigation in agriculture. No specific data for aquifer recharge is given (INE, 2015a).

Additional information can be drawn from non-official sources to complete the data series. AEAS (Spanish Association of Water Supply and Sanitation Services) (2014) reported that the use of reclaimed wastewater in 2012 was around 9.7% of treated wastewater, which is slightly lower than in 2013. 77.3% of the total was reused in agriculture, 10.2% in other sort of irrigation (leisure areas), 9.7% in undetermined uses, 2.2% in manufacturing and 0.6% for cleaning. Updated information produced by AEAS and disclosed by iAgua (2016) shows moderate changes in these shares: irrigated agriculture (41%), other irrigation uses (31%), industrial (12%) and other undetermined uses (16%). Again, no specific data for aquifer recharge is given. Regions with the highest volume of reclaimed water use remain the same as were mentioned above, Murcia and Valencia, for agricultural irrigation, and Madrid, Balearic Island and Catalonia (mainly for leisure services and industrial uses).

In turn, FENACORE (National Federation of Irrigation Districts) have recently projected volumes of water reuse in Spain (EFE, 2016) in 2016 on the basis of information reported to the EC in the second cycle of river basin management plans. This yields a rough estimate of 400 hm³/yr. of reused water out of 3,500 hm³/yr. of total urban wastewater volume, which is relevant taking into account urban-related activities, such as tourism. Interestingly enough, this would be just one quarter of the target for 2015, according to the National Plan of Water Quality: Sanitation and Wastewater Treatment (2007-2015).

Potential

Given the current volume of reclaimed wastewater and potential in quantitative terms, the reuse industry still does not operate close to the authorized limits, and the pricing system could play an important role explaining this fact. In turn, whatever progress in controlling illegal abstractions and applying full cost recovery pricing, would also entail a potential effective market for regenerated wastewater for irrigation, which would instantly become more realistic (on the basis of legal provisions about concession contracts and water banks in the 2001 Water Act – articles 67 to 70).

Water from the Tagus-Segura major diversion project, for example, currently costs just 0.12 €/m^3, a price that fails to reflect the conveyance infrastructure's capital, operational and environmental costs. At an estimated price of 0.40 €/m^3, wastewater reuse may be seen as actually expensive as compared to subsidized water from the transfer or illegal groundwater abstractions, albeit cheap if compared to the average cost of desalinated water (Gómez et al., 2013).

For industrial activities, it seems clear that reused water could become a non-seasonal water resource, especially for activities not demanding a very high water quality, such as the paper and pulp industry, the second largest one in Europe with 10 cellulose and 67 paper plants (i.e. the Canal Isabel II water utility already provides Holmen's paper plant with ~2 hm^3 or reclaimed wastewater). There are additional examples such as the San Jerónimo WWP in Seville providing with regenerated water to Las Cruces copper mine (25% of the country's copper output).

In any case, provision of water for reuse in the agricultural sector seems the key potential of the water reuse industry (see below).

Key barriers

Overall, as in Ortega (2008), there are several drawbacks:

- The possibility that the deployment and the exploitation costs of regeneration treatments and of the storage and transport systems are fully charged exclusively on users[255];
- Funding operational costs and, in general, cost-recovery policies; and
- Social acceptability of water reuse (including lack of information and public participation).

According to water utilities and Irrigators´ associations (AEAS and FENACORE in EFE, 2016) the main barrier is price (though it is considerable cheaper than desalinated water – between 33 and 50%). In addition, another barrier has to do with the outcomes of the financial and economic crisis on investment and fiscal consolidation efforts (clearly damaging the development of planned infrastructure). Custodio (2015) states that in some places, reuse is conditioned by the market price of the water where it is produced (that should be compatible with treatment and transport) [256] and also the high investment due to the following needs: specific treatments in order to adequate water to specific uses (quality standards), and *ad-hoc* dedicated networks to deliver reclaimed water.

Additional factors (iAgua, 2016) include:

- The need to set up a more favourable framework of economic conditions to integrate reclaimed water within the water resources mix (as this kind of resource is more expensive than others);

[255] Illustrative numbers a) for systems without desalination: 10-350 €/m^3/day (deployment costs) and 0.05-0.15 €/m^3 produced (exploitation costs); and b) for systems with desalination: 270-700 € €/m^3/day (deployment costs) and 0.25-0.50 €/m^3 produced (exploitation costs).

[256] For example, in the South of Tenerife Island (Canary Islands) reclaimed (and desalinated) water price is competitive until 400-500 m level high, contrary to the situation in the north of the island (neither reclaimed nor desalinated water are competitive when compared with groundwater).

- Challenges (administrative management of licenses / permits, economic / financial management and different requirements: production, supply, monitoring, etc.) in the implementation of the legal framework (Decree 1620/2007);
- Strong restrictions on the use of reclaimed water in industrial cooling towers and other industrial applications (where the majority of the industrial water consumption takes place); and
- The ban on the use of reclaimed water for human consumption (unlike in other countries, art. 4 Decree 1620/2007).

Finally, AEAS (2011) points out the following factors:

- Lack of confidence in the legal regulatory framework (the majority of potential users find it difficult to accept legal and regulatory provisions and associated guidance;
- Poor planning of future scenarios. The draft National Plan for Water Reuse (MARM 2010a) was not further developed;
- Inappropriate perspective adopted for water reuse (from the user perspective instead of the planner;
- Lack of communication and acceptance from the user's perspective – main stakeholders have not been taken into consideration neither during the planning process nor during the implementation of systems; and
- Unaffordable costs for certain kind of users. This results in some cases in a mismatch between offer and demand (idle installed capacity vs. lack of installed capacity), small users being expelled from the system (due to their inefficiency) and unjustified legal requirements in some cases (too demanding, potentially unnecessary, legal requirements in some cases whereas in others it is rather the opposite).

There are also specific barriers for irrigation:

- The main problem is the reluctance of farmers for the potential negative attitudes of consumers towards their products and difficulties in fulfilling the labelling requirements for accessing European markets. Adoption of Codes of Best Practices [257] at EU-level could help raise acceptance from both sides. In this regard, Spain is co-leading with Malta a recently created working group by the EC to develop these Codes;
- Additionally, fear about the likely effect that regulation of reclaimed wastewater may have on the price of this type of resource (MARM, 2010a);
- The presence of pollutants (i.e. POPs) and priority substances such as those already detected (occasionally and in high concentrations) in reclaimed water used for golf course irrigation in Gran Canaria (Estévez et al., 2012; 2016) is perceived as an obstacle. In the Llobregat Delta the use of reclaimed water for irrigation among other uses also led to reporting of "presence of pharmaceuticals and chemicals" (Teijón et al., 2010 cited in De Stefano et al., 2015); and
- Besides (GWI, 2016) irrigation communities in the Mediterranean coast benefit from senior water rights that provide farmers with water at a very low cost in certain areas – thus, they have enough incentives to demand regenerated water.

Of course, there are also specific barriers for aquifer recharge (Escalante, 2014a):

- Incipient knowledge on the subject – so far few schemes implemented and lack of continuity in their application in the country;
- Lack of priority / relevance of this kind of technique as a water management;

[257] See MAGRAMA Press release http://www.magrama.gob.es/es/prensa/160323guiaeuropeabuenaspracticasreutilizacionaguasdepuradas_tcm7-415784_noticia.pdf

- Technical challenges: inappropriate design / device choice, lost of recharged water in the aquifer, negative effects on the receiving waters due to the device used, evaporation losses / silting;
- Limited knowledge on receiving waters;
- Poor quality of water used for the recharge (often of less quality than potable water or with presence of emerging pollutants, industrial chemicals, pesticides, etc.);
- Downstream third-party effects;
- Socio-economic concerns; and
- Lack of information disclosure.

Despite all these barriers, facts and figures evidence that Spain is one of the MS leading water reuse in Europe, with a pioneer regulation that has already accumulated valuable experience to overcome some of these barriers.

5.2 Wastewater collection and treatment

Wastewater treatment

Authorised wastewater discharges (MAGRAMA, 2013; 2014b; 2015e) were steadily increasing in the total number of authorisations but decreasing in total volume over the last few years: 8,521 hm^3/yr. (year 2014), 8,611 hm^3/yr. (year 2013), 11,180 hm^3/yr. (year 2012) (See Table 5.1).

In 2013, in Spain (INE 2015) [258] the volume of treated wastewater was estimated at 4,998 hm^3 (out of which, 11% is reused, as stated above: 531 hm^3/yr). AEAS (2014) estimated for 2012 a volume of effluent wastewater to wastewater treatment plants and treated wastewater of around 2,254 hm^3/yr.[259] and a volume of 205 hm^3/yr. of "direct reused water" (i.e. 9.7%).

Table 5.1 Authorised discharges into the public water domain

		2014		2013		2012	
Authorisation type	**Discharge type**	**Number**	**Volume (hm^3/yr)**	**Number**	**Volume (hm^3/yr)**	**Number**	**Volume (hm^3/yr)**
Discharge license	Urban	20,595	3,351.39	19,360	3,461.89	18,851	3,409.54
	Industrial	5,220	297.01	5,180	206.44	5,974	313.07
	Cooling	122	1,528.26	135	1,568.84	153	3,996.88
	Aquaculture	137	2,117.78	133	2,029.18	138	2,063.32
	Mining	130	87.47	133	89.98	85	83.56
	Other	768	17.39	779	24.28	724	20.08
Environmental	Activities	1,030	1,121.75	1,084	1,229.99	1,061	1,293.27

[258] Based on a sample representing the 85% of the population of the whole country. Levels of treatment considered: primary, secondary and tertiary and "soft" technologies and septic tanks. No distinction is made according to treatment applied (only aggregated data are provided). Data on wastewater treatment plants managed by regional entities are not included in the survey, so results are biased.

[259] Results of the year 2012 are based on a sample with 72 valid questionnaires (representing a population of 22.44 million people connected to a wastewater treatment plant, (equivalent to a 51.547 million equivalent population); volume of wastewater treated: 2,254 hm^3/yr. As no info on non-treated discharged wastewater was provided for the survey, effluent water is assumed to be equivalent to treated water in the wastewater treatment plants.

		2014		2013		2012	
Integrated license	Annex I Law 16/2002						
TOTAL		28,002	8,521.06	26,804	8,610.60	26,986	11,179.71

Sources: MAGRAMA (2015e), MAGRAMA (2014b), MAGRAMA (2013)

Treated effluent quality by volume and treatment level (primary, secondary and tertiary)

In 2012 (AEAS, 2014) most of the volume of treated wastewater (59.7%) underwent a secondary treatment and 40.3% an advanced one (tertiary), whereas no wastewater at all went through a primary one[260]. In contrast, in 2004 only 5.1% of the volume was treated under an advanced one (and a 2.6% only went through primary treatment) and 86.3% a secondary. This implies an improvement in the kind of treatment applied, thus leading to better quality outcomes.

Wastewater treatment costs associated with different treatment levels

The costs of water reuse treatments are asymmetric depending on the treatment used to meet legal water quality requirements (MAGRAMA, 2016, See Table 5.2): the upfront investment cost can vary from 5 €/m^3 produced/day (filtration) to 736 €/m^3 produced/day (chemical treatment, ultrafiltration and desalination) and operational and maintenance cost may vary from 0.04 €/m^3 (filtration, and disinfection or depth filtration) to 0.35-0.45 €/m^3 produced/day (chemical precipitation, ultrafiltration, desalination and disinfection). According to Iglesias (2010), these broad ranges are due to the different sizes of water reclamation plants, climatic and geographical conditions, and inlet treated water features. Issues that should be considered include process flexibility, operating and maintenance requirements as well as chemical supplies and personnel.

A specific example of costs in a region with consolidated capacity of reclaimed wastewater reuse (Valencia, see Molinos-Senante et al., 2013) average OPEX for secondary treatment is 0.26 €/m^3, 0.32 €/m^3 for tertiary treatment, and 0.57 €/m^3 for advanced treatments (e.g. RO and ultrafiltration). Note that OPEX includes other costs on top of O&M costs.

Table 5.2: Water reuse treatments: costs

Type of treatment line	Investment cost (€/m^3/day)	Operational cost (€/m^3)
TYPE 1 (CP+F+UF+D)	185 – 398	0.14 – 0.20
TYPE 2 (CP+F+UV+D)	28 – 48	0.06 – 0.09
TYPE 3 (F+UV+D)	9 – 22	0.04 – 0.07
TYPE 4 (F)	5 – 11	0.04 – 0.07
TYPE 5.a (CP+F+UF+RO+D)	416 – 736	0.35 – 0.45

*** Source:** MAGRAMA (2016) updating investing costs set up in Iglesias et al. (2010). Types of treatment are related to qualities referred to in Royal Decree 162072007 (as in Iglesias et al., 2010), explained below in notes:

* **Notes**:

[0] Treatment technologies to be applied according to water uses set up in Royal Decree 1620/2007 on reclaimed water use. Treatment lines 1 to 4 do not include desalination. Treatment line 5 includes desalination.

[1] Treatment Line 1 (quality A): Chemical precipitation (with lamella settling system, filtration with membranes (ultrafiltration) and Disinfection (residual chlorine may be needed in distribution system). Type 2 can achieve quality A about *E. coli*, *Legionella* spp and intestinal nematodes standards but it is difficult to achieve turbidity limit that sets in 1-2 NTU.

260 Results of the year 2012 are based on a sample with 72 valid questionnaires (representing a population of 22,44 million people connected to a wastewater treatment plant, (equivalent to a 51547 million population equivalent); volume of wastewater treated: 2254 hm3/yr.

[2] Treatment Line 2 (quality B): Chemical precipitation, depth filtration and disinfection (UV+chlorination, residual chlorine may be needed in distribution system). This treatment train is used for industrial applications (referred to as 3.1 a), b) and c) within Royal Decree 1620/2007) due to *E. coli* and Turbidity requirements.

[3] Treatment Line 3 (quality C and D): filtration and disinfection (tendency to UV and residual chlorine). Disinfection means €0.005 per m^3 produced so this unit process is not seen in the displayed value.

[4] Treatment Line 4 (quality C and E): filtration but surface or depth filtration for distribution system management.

[5] Treatment Line 5.a (qualities A to F): Chemical precipitation (with lamella setting system, filtration and filtration with membranes (incorporating membranes before RO as protective barrier), RO desalination and residual chlorine for type 5.a. Cases where physical–chemical treatment operation can be left out, cost may be ranging from €0.30 to €0.40 per m*3* produced.

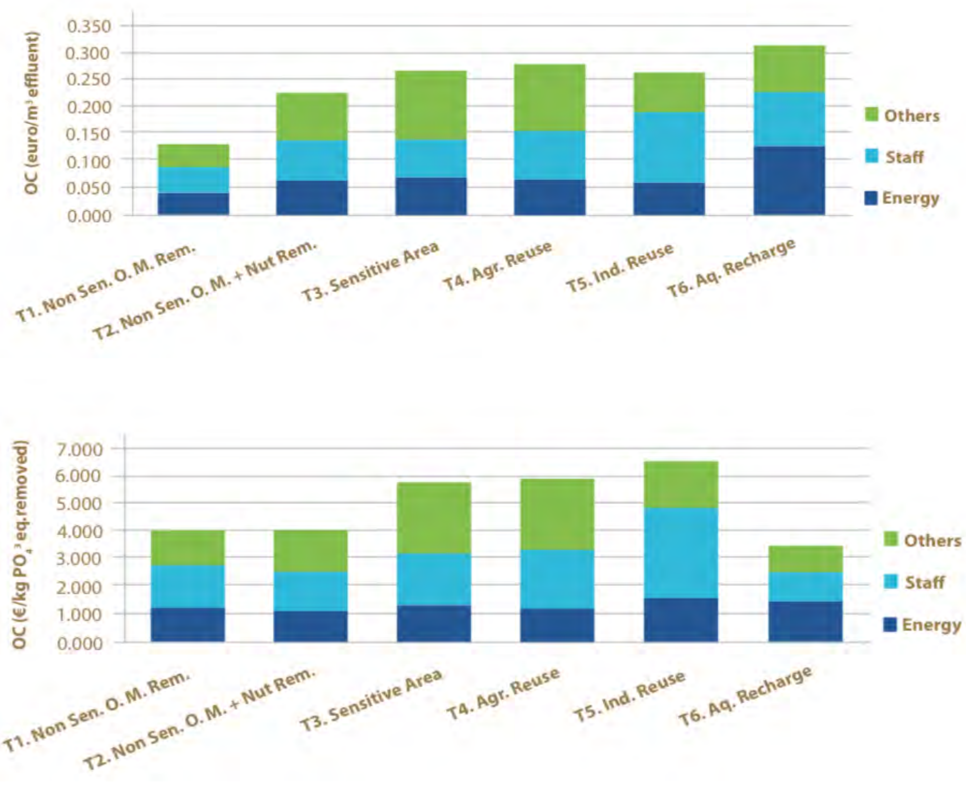
[6] Treatment Line 5.b (qualities B, C, D, E): Chemical precipitation (with a lamella setting system), filtration (double depth with continuous washing), EDR desalination and Disinfection (tendency to use ultraviolet radiation followed by residual chlorine). Cases where physical–chemical treatment operation can be left out, cost may be ranging from €0.30 to €0.40 per m^3 produced.

So far, according to official statistics (INE, 2015), the unit cost for sewage and wastewater treatment in 2013 was 0.74 €/m^3 vs. a unit (average) cost in 2000 of 0.17 €/m^3.

In SE Spain (where the water exploitation index is typically the highest one combined with intense scarcity and drought risk) the cost of treating wastewater can amount on average to 0.22 €/m^3 (secondary treatment) plus 0.06 €/m^3 (tertiary treatment). The cost of reusing wastewater adds onto that 0.069 in conveyance and 0.041 in the depreciation of capital assets (Melgarejo, 2009). This means that treating water entails 0.28 €/m^3 in contrast to reusing reclaimed wastewater, that accounts for 0.39 €/m^3 (1.39 times more).

Since literature reflects a variety of methodological approaches and types of costs, comparability of results is limited. Rodríguez-García et al. (2011) cited in UNEP (2015) reported operational costs of primary, secondary and tertiary treatment according to the type of destination area for discharge or the reuse purpose of the reclaimed water in Spain. When objectives (i.e. a greater action for supporting the transition towards collective goals) are taken into account rather than just volume, some expensive treatments could be cost-effective.

Figure 5.4 Operational cost of wastewater treatment per volume treated (€/m3, above) and per unit of eutrophication reduction (in €/kg PO_4 eq. removed, below), when objectives of removing organic matter and nutrients are set



Source: UNEP, 2015, adapted from op. cit. Rodríguez-García et al. (2011). T1: WWTPs that remove organic matter (OM) and discharge treated wastewater to non-sensitive areas; T2: WWTPs that remove OM and nutrients and discharge treated wastewater to non-sensitive areas; T3: WWTPs that remove OM and nutrients and discharge treated wastewater to sensitive areas; T4: WWTPs reusing treated wastewater for irrigation in agriculture; T5: WWTPs reusing treated water for industrial purposes; T6: WWTPs reusing treated water for aquifer recharge.

National regulations and guidelines

The legal framework for water reuse is quite an advanced one at EU level. Nation-wide, water reuse is regulated by the Royal Decree 1620/2007 (December 7th), (BOE, 2007) which establishes quality criteria (maximum acceptable values, presence-absence for certain parameters according to the type of water use) as well as risk management measures both for reuse of treated wastewater in agricultural irrigation and aquifer recharge (among other uses) (See table 5.3 for further details) and risk management measures.

Additional related regulations / guidelines / planning instruments include a) the already mentioned water reuse planning instrument, still in a stagnant, draft stage (the National Water Reuse Plan, MARM, 2010a); b) all the 2nd River Basin Management Plans already adopted (i.e. main RBDs, Balearic Islands, Galicia Coast and Andalusian RBDs (see BOE 2016a; 2016b) as they contemplate water reuse measures, and c) an official specific document containing guidelines for the application of Royal Decree 1620/2007 (MAGRAMA, 2010b).

The Decree expressly forbids reclaimed water for the following uses:

- Human consumption, with the exception of a catastrophic event;
- Food industry, except process and cleaning waters, as in Art 2.1b) of Royal Decree 140/2003;
- Hospitals and alike;
- Filter-feeding molluscs' aquaculture;
- Bathing waters (recreational uses);
- Cooling towers and evaporation condensers, with exemption criteria for some industrial uses;
- Fountains and ornamental plates in public or interior spaces of public buildings; and
- Any other use public health or environmental authorities may consider as a risk, whatever the time when the risk or the damage are perceived.

Hence, allowed uses are urban irrigation or other uses (section 1), agricultural irrigation (section 2), industrial uses (section 3), recreational uses (section 4), and environmental uses (i.e. aquifer recharge *inter alia*) (section 5).

As per water reuse in agriculture Appendix I.A. of the Decree sets up water quality criteria (maximum acceptable values of intestinal nematodes[261], *Escherichia coli*[262], suspended solids[263], turbidity[264] and additional criteria such as *Legionella spp.*[265], *Taenia*[266] and complying with Environmental Quality Standards regarding several pollutants[267]) for the reuse of water according to three kind of scope of application: quality 2.1[268], quality 2.2[269] and quality 2.3[270].

[261] Limit value: 1 egg/10 l.

[262] Range of acceptable limit values: 100-10,000 CFU/100 ml. Range of acceptable maximum values: 1,000-10,000 CFU/100 ml, with a maximum of 3 samples out of 10 going in between allowable limit values and allowed maximum values

[263] Range of limit values: 20-35 mg/l.

[264] Range of limit values: none-10 NTU.

[265] Limit value: 1000 CFU/l.

[266] Limit value: 1 egg/l.

[267] Enforced EQS.

[268] For irrigation systems with direct contact between reclaimed water and edible parts of crops to be eaten raw

In terms of stipulated risk management measures Appendix I.B. sets up the minimum sampling and analysis frequencies (variable provided that certain specific conditions do occur) for each quality parameter (intestinal nematodes [271], *Escherichia coli* [272], suspended solids [273], turbidity [274] and additional criteria [275]). According to Appendix I.A. reclaimed water for agricultural uses with quality 2.1 a Maximum Acceptable Value for *Legionella spp*. is established if there is a risk of aerosolisation.

According to Article 8 ("Procedures for obtaining a water reuse concession"), section 3, the applicants for a water reuse concession, should submit a Water Reuse Project fulfilling a specific section on planned risk management measures to be taken in case the water fails to meet the criteria required for the use it has been authorised (according to what specified in Appendix I).

As per water reuse for aquifer recharge, Appendix I.A of the Decree sets up the quality criteria (maximum acceptable values of intestinal nematodes[276], *Escherichia coli*[277], suspended solids[278], turbidity[279] and additional criteria such as complying with Environmental Quality Standards regarding pollutants[280], Total nitrogen[281], NO_3^- [282]) according to 2 kind of scope of application: quality 5.1 (recharge by surface infiltration or indirect recharge) and 5.2 (aquifer recharge by direct injection – direct recharge).

In terms of stipulated risk management measures Appendix I.B. sets up the minimum sampling and analysis frequencies (variable provided that certain specific conditions do occur) for each quality parameter (intestinal nematodes [283], *Escherichia coli* [284], suspended solids [285], turbidity [286] and additional criteria [287]).

[269] For the irrigation of crops: a) to be eaten by humans not raw but after an industrial treatment process (irrigation methods do not prevent direct contact of reclaimed water with edible parts of the crop); b) pasture (for milk or meat producing animals); c) aquaculture)

[270] For the irrigation of a) woody crops with fruit for human consumption whereby reclaimed water is not allowed to be in direct contact with fruits; b) ornamental flowers/nurseries and greenhouses with no direct contact between reclaimed water and the products; c) non-edible industrial crops, nurseries, fodder (silo), cereals and oilseeds.

[271] For all type of quality: every two weeks

[272] For all kind of quality: once a week

[273] For all type of quality: once a week

[274] For type 2.1, once per week.

[275] Once per month (type 2.1) and every two weeks (type 2.2.)

[276] Range of limit values: 1 egg/10 l.

[277] Range of limit values: None-1.000 CFU/100 ml.

[278] Range of limit values: 10-35 mg/l.

[279] Range of limit values: None-2 NTU.

[280] Enforced EQS.

[281] Limit value: 10 mg/l.

[282] Limit value: 25 mg/l.

[283] None (type 5.1) or once a week (type 5.2).

[284] Twice (type 5.1) or three (type 5.2) times per week.

[285] Once a week (5.1) and once a day (5.2).

[286] For type 2.1, once a day.

[287] Total nitrogen weekly (both types) and other criteria (weekly, type 5.2).

Table 5.3 Legal requirements setting up quality criteria for using reclaimed water (Royal Decree 1620/2007): only irrigation and aquifer recharge

Use of water / quality required	Maximum Acceptable Value (MAV)					
	Intestinal nematodes (eggs/10 l)	***Escherichia coli* (CFU/100 ml)**	***Legionella spp.* (CFU/100 ml)**	**TSS (mg/l)**	**Turbidity (NTU)**	**Other criteria**
2.AGRICULTURAL USES						
Quality 2.1. For irrigation systems						
a) With direct contact between reclaimed water and edible parts of crops to be eaten raw	1	100 [*]	1000 [**]	20	10	1. Other pollutants included in the treated effluent disposal permit: to be discharged in a limited amount. 2. Hazardous substances: reclaimed water to be compliant with environmental quality standards. 3. Legionella requirement compulsory when aerosolisation risk. 4. When continuously c= 3 for M =1000, then compulsory a presence/absence test of pathogen (e.g . Salmonella).
Quality 2.2. For the irrigation of crops						
a) to be eaten by humans not raw but after an industrial treatment process (irrigation methods do not prevent direct contact of reclaimed water with edible parts of the crop)	1	1000 [***]	10000	35	No limit set	1. Other pollutants included in the treated effluent disposal permit: to be discharged in a limited amount. 2. Hazardous substances: reclaimed water to be compliant with environmental quality standards. 3. When continuously c= 3 for M =1000, then compulsory a presence/absence test of pathogen (e.g. *Salmonella*).
b) Pasture (for milk or meat producing animals)	1	1000 [***]	10000	35	No limit set	1. Other pollutants included in the treated effluent disposal permit: to be discharged in a limited amount. 2. Hazardous substances: reclaimed water to be compliant with environmental quality standards. 3. *Taenia (saginata* and *solium*): 1 egg/l. 4. When continuously c= 3 for M =1000, then compulsory a presence/absence test of pathogen (e.g . *Salmonella*)
Quality 2.3. For the irrigation of:						
a) Woody crops with fruit for human consumption whereby reclaimed water is not allowed to be in direct contact with fruits	1	10000	100	35	No limit set	1. Other pollutants included in the treated effluent disposal permit: to be discharged in a limited amount. 2. Hazardous substances: reclaimed water to be compliant with environmental quality standards.
b) Ornamental flowers/nurseries and greenhouses with no direct contact between reclaimed water and the products;	1	10000	100	35	No limit set	1. Other pollutants included in the treated effluent disposal permit: to be discharged in a limited amount. 2. Hazardous substances: reclaimed water to be compliant with environmental quality standards.

Use of water / quality required	Maximum Acceptable Value (MAV)					
	Intestinal nematodes (eggs/10 l)	***Escherichia coli*** **(CFU/100 ml)**	***Legionella spp.*** **(CFU/100 ml)**	**TSS (mg/l)**	**Turbidity (NTU)**	**Other criteria**
c) Non-edible industrial crops, nurseries, fodder (silo), cereals and oilseeds)	1	10000	100	35	No limit set	1. Other pollutants included in the treated effluent disposal permit: to be discharged in a limited amount. 2. Hazardous substances: reclaimed water to be compliant with environmental quality standards.
5. ENVIRONMENTAL USES (aquifer recharge)						
Quality 5.1						
a) Recharge by surface infiltration or indirect recharge	No limit set	1000	No limit set	35	No limit set	Total Nitrogen: 10 mg /l; NO3-: 25 mg/l
Quality 5.2						
a) Aquifer recharge by direct injection (direct recharge).	1	0	No limit set	35	2	Total Nitrogen: 10 mg /l; NO3-: 25 mg/l

Source: BOE 2007

Information on current monitoring requirements for treated effluent discharges and receiving water bodies (parameters, frequency) and associated sampling and testing costs

Legal requirements are mainly set up in the following national regulations: Decree 817/2015 (BOE, 2015) on criteria for monitoring and assessing the state of surface water and environmental quality standards (requirements), and Decree 209/1996 (BOE, 1996) setting up regulations on urban wastewater treatment. MMA (2007) provides details on the application of legal monitoring requirements if treated effluent discharges and reference methods. Some other legal references are required to be taken into account: Royal Decree 849/1986, that regulates the Public Domain, modified by the Royal Decree 606/2003, Royal Decree 907/2007 that regulates water planning and standards UNE-EN ISO/IEC 17025.

The Royal Decree 1620/2007 considers circumstances under which the frequency of monitoring should be altered (either reduced or increased). After a year of surveillance if the holder submits a reasoned request justifying an unlikely presence of organisms/pollutants, the basin agency may reduce in turn the frequency of analysis of this parameter up to 50%. After a quarter or a fraction, if the number of samples with concentration below the Maximum Acceptance Value is less than 90% of the samples, the sampling rate for the next period will be doubled. If a control exceeds at least one of the parameters' ranges of deviation, then the frequency of sampling will be doubled during the rest of this period and the next one.

In addition, in all cases producers have to comply with specific conditions stated in each discharge authorisation (regarding Accepted Maximum Values of other pollutants and additional criteria not expressely considered in the Royal Decree 1620/2007 – pH, BOD, etc.).

MARM (2010b) have published guidance to explain implementation details of the Decree 1620/2007 and technical requirements for treatment of wastewater depending on uses of the water reclaimed.

5.3 Agricultural irrigation: baseline

Agricultural sector profile

Advantages for agricultural development in Spain stem from a relative abundance of arable land (Spain has 261,000 km^2 of agricultural land, the largest in the EU only after France; this represents 52.9% of the total area, as compared to the EU average of 43%) (EUROSTAT, 2013); abundance of sun hours (Spain has on average 2,910 sunshine hours per year, while national averages of other MS – with the exception of Portugal, are below 2,500) (FAO, 2013), and moderate labour cost, which in 2013 were EUR 21.1 an hour, slightly below the EU-28 average (EUR 23.7 an hour) (EUROSTAT, 2014) (also partly explained by an elastic labour supply fed with immigration for many years). Nevertheless water becomes the critical scarce production factor.

Water availability has always been perceived as the key structural element required to trigger and sustain economic growth in rural areas. Irrigation expansion has very often been equivalent to economic growth, regional development and spatial cohesion while contributing to relevant ancillary benefits such as stable population settlement, erosion prevention, etc. While asymmetries between rainfed and irrigated agriculture are significant throughout Spain, water productivity notably differs from place to place giving room to a dual model of agricultural development.

In watersheds of SE Spain such as the Andalusian Mediterranean RBDs, average water productivity – measured as the gross margin in € per m^3, equals 1.75 €/m^3 (Pérez et al., 2010), while in central areas of Spain such as the transboundary Duero RBD, this value is only 0.14 €/m^3 (Pérez and Thaler, 2014). Values for water productivity in irrigation, though, are extremely variable according to the geographical area and crop. For example, the average value for higher and colder areas is at 0.15 €/m^3, whereas the average values in the SE of the country 2-3 €/m^3 – in cut flowers production: 8-10 €/m^3 (Pulido-Velázquez et al., 2014).

There is still a large share of water used in subsidised production with low added value, where the current pricing scheme does not provide the right incentives to change to a more profitable, less water intense one. Conventional agriculture, dominated by extensive crops with low returns per hectare (cereals yield in 2012 amounted 2,843 kg/ha, average for both rainfed and irrigated fields) (MAGRAMA, 2014), dependent on public infrastructures and EU subsidies (i.e. CAP) contrasts with a dynamic, intensive and highly productive agriculture driven by market stimulus and competitive advantages, with limited financial support from the local government or the EU (if at all).

Agricultural land use distinguishing between arable and grazing land

- Total agricultural land year 2015 in Spain (MAGRAMA (2015a): 50,593,546 ha; forest area: 38% (19,112,316 ha); cropland: 34% (16,984,656 ha)[288]; grasslands and pasture: 16% (8,275,928 ha); other land: 12% (8,275,928 ha); and
- Land use change (2000-2011), according to OECD (2015): -5.98% arable land and permanent crops; -9.93% permanent grass; 8.01% forest area; 27.02% other land.

Crop production distinguishing between food crops to be eaten raw, food crops that will be cooked or processed; and non-food crops in hectares, tonnes per year and value

Crop production in 2013 in Spain can be summarised as follows (elaborated on the basis of MAGRAMA, 2015c):

- Cereals (grain): 6,268,026 ha; 25,374,359 tonnes; 4,888,762 thousand €;
- Leguminous (grain): 378,113 ha; 503,069 tonnes; 197,283 thousand €;

[288] Comprised of: arable land (cereals, leguminous, leafy vegetables, industrial crops, tubers, flowers, fodder crop, fallow land), 23% of total agricultural land (11852508 ha); woody plants (vineyards, olive grove, citrus/non-citrus crops), 10% of total agricultural land (4961981 ha) and other cropland, 0,3% of total agricultural land (170166 ha).

- Tubers (for human consumption): 73,978 ha and 2,210,085 tonnes. Non-available data on the value of crops for the whole group, only for potato: 759,146 thousand €;
- Industrial crops: 1,040,482 ha and 3,952,961 tonnes. Non-available data on the value of all crops of the whole group, only for: sugar beet (85,662 thousand €), cotton (60,817 thousand €), sunflower (352,633 thousand €), soya (617 thousand €), sweet pepper for paprika (15,378 thousand €), saffron (5,302 thousand €), and tobacco (64,900 thousand €);
- Forage crops: 1,044,791 ha and 27,971,607 tonnes. Non-available value for the whole group, only for: alfalfa (417,975 thousand €), French honeysuckle (48,025 thousand €), Polyphytic meadows (329,403 thousand €);
- Vegetables: 348,853 ha and 13,201,085 tonnes. Only estimation of the value of several crops: a) some leaf / stalk vegetables such as: cabbage (57,575 thousand €), asparagus (88,834 thousand €), lettuce (377,357 thousand €), escarole (28,639 thousand €), spinach (27,952 thousand €) and chard (22,693 thousand €); b) some fruit vegetables such as: watermelon (236,330 thousand €), cantaloupe (2,842 thousand €), courgette (253,994 thousand €), cucumber (368,300 thousand €), aubergine (126,461 thousand €), tomato (1,130,345 thousand €), pepper (703,328 thousand €) and strawberry (304,404 thousand €); c) some flower vegetables such as: artichoke (89,795 thousand €), broccoli (75,196 thousand €); d) some roots and bulbs such as: garlic (221,679 thousand €), onion (318,928 thousand €), carrot (112,485 thousand €); e) some leguminous such as: green beans (239,211 thousand €), green peas (55,957 thousand €), broad beans (30,653 thousand €); f) other vegetables such as champignon (158,029 thousand €);
- Non-citric fruit trees: 793423 ha and 3,939,023 ha. Non-available for the whole group, only for: a) some pip fruit trees: apple tree (227,733 thousand €), pear tree (242,867 thousand €), loquat tree (34,664 thousand €); b) stone fruit trees: cherry tree (149,538 thousand €), peach tree (505,780 thousand €), plum tree (116,027 thousand €); c) some fleshy fruit trees amounting to 390,618 thousand € (with banana and avocado trees with the highest values – with 173,165 and 99,614 thousand €, respectively – and other fruits from trees such as fig, cherimoya, pomegranate, date palm and kiwi);
- Dry fruit trees: 553,897 ha (estimated) and 347,337 tonnes (estimated). Under-estimated value of 287,457 thousand € (it does not include all crops but almond, hazelnut and walnut);
- Vineyard: 889,529 ha and 7,482,539 tonnes. Only value for table grapes vineyard (154,417 thousand €);
- Olive tree: 2,434,436 ha and 9,250,610 tonnes. Value only for table olives olive tree (235,214 thousand €);
- Other woody crops: 39,771 ha and 54,815 tonnes. The value of carob tree and caper trees amount to 7,411 and 503 thousand €;
- Citric fruit trees: 281,747 ha and 6,630,040 tonnes. An underestimated value (non-available for all the crops belonging to the group) of this group would be 1,444,443 thousand € (incl. fruits from the following trees: sweet orange, mandarin and grapefruit with values amounting to 605,137, 558,087, 270,511, and 10,708 thousand €, respectively); and
- Flowers: 1,442 ha and a production of 116,090 thousand dozens (flowers). No estimation of their value is provided in the statistics.

Average crop productivity (per crop type) where possible distinguishing between situations with and without irrigation

The average crop productivity per crop group type (measured in kg/ha) is not available in official sources; yet values on productivity with and without irrigation for specific crops within each group can be provided. Summarised information for each group of crops in 2013 in Spain follows (elaborated on the basis of MAGRAMA, 2015c):

- Cereals (grain). Rainfed: corn and spelt (6,906 and 3,700 kg/ha respectively) show the highest values, whereas other mix winter of winter cereals and meslin (1,145 and 1,287 kg/ha) show the lowest. Irrigation: corn and rice show the highest values (11,285 and 7,817 kg/ha) and canary grass and meslin (2,550 and 2,553 kg/ha) the lowest ones;
- Leguminous (grain): Rainfed: dry peas and dry fava bean (1,513 and 1,419 kg/ha respectively) show the highest productivities, whereas lupine and grass pea (less than 800 kg/ha) show the lowest. Irrigation: dry peas, other leguminous and dry fava bean show the highest values (2,852, 2,793 and 2,593 kg/ha) and lupine and carob bean 899 and 1,219 kg/ha) the lowest ones;
- Tubers (for human consumption): Rainfed: potato and sweet potato (18,559 and 7,548 kg/ha respectively) have the highest values as in irrigation (35,010 and 20,729 kg/ha) and tiger nut the lowest (18,010 kg/ha);
- Industrial crops: Rainfed: sugar beet and chicory (47,017 and 15,000 kg/ha respectively) have the highest values, whereas saffron (roasted stigma) followed by aniseed (7 and 525 kg/ha) show the lowest. Irrigation: sugar beet and sugar cane show the highest values (79,493 and 50,000 kg/ha) and saffron and flax (14 and 100 kg/ha) the lowest ones;
- Forage crops: Rainfed: fodder corn and French honeysuckle (36,779 and 32,500 kg/ha respectively) have the highest values, whereas clover and other forage crops (6,221and 6,783 kg/ha) have the lowest. Irrigation: alfalfa and fodder corn have the highest values (58,867 and 55,178 kg/ha); other roots and tubers and other forage leguminous plants (12,000 and 17,935 kg/ha) the lowest ones;
- Vegetables: Rainfed: Carrot and Cabbage (34,155 and 33,129 kg/ha respectively) have the highest values, whereas asparagus and green peas (2,601 and 3,315 kg/ha) have the lowest. Irrigation: tomato and cucumber have the highest values (97,896 and 90,160 kg/ha) and courgette and cellar (3,956 and 4,040 kg/ha) the lowest ones;
- Non-citric fruit trees: Rainfed: kiwi and apple trees (9,818 and 7,993 kg/ha respectively) have the highest values, whereas cherimoya tree and prickly pear (800 and 1,504 kg/ha) have the lowest. Irrigation: banana and apple trees have the highest values (39,734 and 25,082 kg/ha) prickly pear and date palm trees (4,408 and 4,700 kg/ha) the lowest ones;
- Dry fruit trees: Rainfed: chestnut and walnut trees (2,199 and 1,112 kg/ha respectively) have the highest values, whereas almond and pistachio trees (239 and 455 kg/ha) have the lowest. Irrigation: walnut and chestnut trees have the highest values (2,278 and 2,264 kg/ha) and almond and pistachio trees (770 and 1,223 kg/ha) the lowest ones;
- Vineyard: Rainfed: wine grapes and table grapes vineyards (6,790 and 3,779 kg/ha respectively) have the highest values, whereas dried grapes (1,035 kg/ha) has the lowest. Irrigation: table grapes vineyard has highest value (21,719 kg/ha).
- Olive tree: the productivity of olive oil olive trees ranges between 3,063 and 6,425 kg/ha in rainfed and regime production regimes respectively;
- Other woody crops: Rainfed: cane and osier (10,269 and 2,757 kg/ha respectively) have the highest values. The same crops have also the highest productivity values in irrigation regime (40,000 and 20,822 kg/ha), respectively; and
- Citric fruit trees: sweet orange and bitter orange trees have the highest average productivity (36,882 and 25,373 kg/ha, respectively) whereas other citric and grapefruit trees have the lowest ones (7,919 and 21,310 kg/ha, respectively).

Agricultural irrigation

Conventional agriculture, dominated by extensive crops with low returns per hectare (cereals yield in 2012 amounted 2,843 kg/ha, average for both rainfed and irrigated fields) (MAGRAMA, 2014), dependent on public infrastructures and EU subsidies (i.e. CAP) contrasts with a dynamic, intensive and highly productive agriculture driven by market stimulus and competitive advantages, with limited financial support either from the local government or the EU (if at all). The largest exploitations can be found in the Castile León region, in central Spain, with an average size of 57.7 ha, while those in the southeast are amongst the smallest, with an average size between 5.07 and 11.72 ha (INE, 2014).

The overriding traditional model of continental agriculture requires limited labour and manufactured inputs, their management practices do not demand sophisticated commercial and financial services and its output does not feed complex industrial processes or supply chains. On the contrary, the relatively modern and thriving agriculture that dominates water scarce Mediterranean basins, requires increasingly more sophisticated inputs and labour skills, follows modern entrepreneurial practices, and supplies basic commodities for a complex and competitive agro-food manufacturing and logistics industry.

Whereas apparent productivity in the regions of Castile León (central Spain) and Andalusia (southern Spain) is the same (0.56 €/m^3), indirect water productivity in Andalusia is actually larger (1.75 €/m^3) than that of Castile and León (1.65 €/m^3), showing that the Andalusian agriculture has more relevant forward linkages with the rest of the economy (Pérez et al., 2010).

In regions like Andalusia or Murcia the direct contribution of agriculture to the regional output and employment (4.2% and 4.5%, respectively) might be low (although higher than average), but its indirect and induced impact over the whole production chain make it the central piece of the existing income and employment opportunities.

According to De Stefano et al. (2015), estimated water demand (surface and groundwater sources) for agriculture amounts to 25,000 hm^3/yr. (or 79% of total water demand)[289]. Groundwater abstraction is estimated at *circa* 6,125-6,925 hm^3/yr. (19-22% of Spain´s total water demand) out of which a 70-72% (4,300-5,000 hm^3/yr.) is used for around one-third of the irrigated land (around 0.9 million hectares, on the basis of 3.3 million of irrigated ha, López-Geta et al., 2009 cited in De Stefano et al., 2015) (See Table 5.4).

Table 5.4. Estimated groundwater abstraction and total water demand (Spain)

	Estimated Groundwater abstraction		Total water demand (surface plus groundwater)	
	(hm^3/yr)	%	(hm^3/yr)	%
Domestic supply	1,400-1,500	23-22	5,200	16
Agriculture	4,300-5,000	70-72	25,000	79
Industry	360	6-5	1400	4
Recreational uses	65	1	130	0
Total	6,125-6,925	100	31,730	100

Source: de Stefano et al. (2015).

* **Notes:** A) Estimated groundwater abstraction is mainly based on estimates of groundwater demand. B) Overall water demand comprises surface and groundwater demand.

Following INE (2015b), available water for irrigation [290] in Spain (year 2013) comes from surface sources (77%), groundwater (21%) and desalination and reuse (2%) Arable crops account for 56% of water for irrigation whereas 16% is for fruit trees, 10% for olive trees and vineyards, 9% for other crops and 8% for potatoes and vegetables. Irrigation techniques have moved away from gravity (still 37%) towards drop irrigation (37% also) and sprinkler (26%) (*See Tables 5.5 and 5.6 for further details*).

[289] Estimated water demand for other uses are, according to the same source: 16%, for domestic supply, 4% for industry and 0.4% for recreational uses. Total estimated water demand amounts to 31730 hm3/yr.

[290] According to INE (2015b): available water is the effective volume of water available for the irrigation communities for their supply networks (after discounting losses in their distribution networks) plus surface and groundwater volumes of water non subject of administrative concession plus water volume subject of administrative concession of other sources such as reclaimed water and desalinated (marine) water.

Table 5.5. Available water for irrigation by source: Spain, years 2000 and 2013

	2000	%	2013	%
Surface water	20.46	92	14.07	77
Groundwater	0.91	4	3.92	21
Other resources (desalinated and reclaimed)	0.80	4	0.33	2
Total	22.17	100	18.32	100

Source: INE (2015b)

Table 5.6. Supplied water for irrigation by crop type and irrigation technique: Spain, years 2000 and 2013

	Supplied water for irrigation (thousand hm^3)			
	2000	**%**	**2013**	**%**
By crop type				
Arable crops	7.24	43	8.21	56
Fruit trees	3.12	18	2.34	16
Olive trees & vineyard	1.52	9	1.49	10
Potatoes & vegetables	2.18	13	1.22	8
Other crops	2.83	17	1.27	9
Total	16.90	100	14.53	100
By irrigation technique				
Sprinkler	3.06	18	3.75	26
Drop	1.44	9	5.38	37
Gravity	12.40	73	5.40	37
Total	16.90	100	14.53	100

Source: INE (2015b)

The area under irrigation in Spain in 2015 (MAGRAMA, 2015d), was 3,636,519 ha, out of a total cultivated land of 16,984,656 ha. This means that irrigation is 21.41% of total cultivated land (at country level).

- The regions with the highest share of irrigated land/cultivated land area are the Canary Islands (57%), Comunidad Valenciana (45%), Murcia (38%), La Rioja (33%), Catalonia (31%), Andalusia (30%), Navarre (29%) and Extremadura (24%). In absolute terms, the regions with the highest area of irrigated land are Andalusia (29.28%, 1,064,771 ha), Castile-La Mancha (14.02%, 509,891 ha), Castile León (12.35%, 449,145) and Aragón (10.87%, 395,211); and
- The regions with the highest share of irrigated land/total regional area are Murcia (16%), Comunidad Valenciana (12%) and Andalusia (13%), matching the driest area of the country, and the one with a higher index of water exploitation (Fig 5.1).

In terms of crops under irrigation in 2015 (MAGRAMA, 2015d), the crops with the highest irrigated area at country level were cereals (1,009,149 ha; 28% of the total country irrigated area), olive tree groves (748,708 ha; 21% total country irrigated area); vineyard (365,767 ha; 10% total country irrigated area), non-citrus fruit trees (290,677 ha; 8% total country irrigated area); citrus fruit trees (282,675 ha; 8% total country irrigated area) and fodder crops (247,784 ha; 7%). In turn, crops having the highest irrigated area in relation to their total cultivated area were citrus (93%) and vegetables and flowers (88%), nursery crops (77%) and tubers (76%) (See Table 5.7).

Table 5.7. Irrigated and cultivated area by type of crop, year 2015

Crop type	Irrigated area: ha (1)	Irrigated area (%)	Total cultivated area: ha (2)	Total cultivated area (%)	Irrigated/Total cultivated area (1)/(2)%
Cereals	1,009,149	28	6,419,243	38	16
Olive grove	748,708	21	2,605,252	15	29
Vineyard	365,767	10	967,733	6	38
Fruit trees (non-citrus)	290,677	8	1,044,759	6	28
Citrus trees	278,265	8	299,518	2	93
Fodder crops	247,784	7	1,006,357	6	25
industrial crops	208,844	6	1,007,421	6	21
Vegetables and flowers	204,649	6	233,830	1	88
Fallow	93,997	3	2,743,368	16	3
Other crop areas	68,852	2	113,066	1	61
Tubers	42,338	1	55,702	0	76
Greenhouse crops	35,919	1	35,919	0	100
Leguminous	23,551	1	386,587	2	6
Nursery crop	16,319	0	21,182	0	77
Other woody crops	1,700	0	44,718	0	4
TOTAL (all types)	3,636,519	100	16,984,656	100	21

Source: MAGRAMA, 2015d

As per irrigation techniques (MAGRAMA, 2015d) in 2015 the total Irrigated area was 3,636,519 ha. By technique, localised irrigation (drip, mainly) accounted for 49.30% of the total area (1,792,911 ha)[291]; gravity for 26.90% (978,125 ha)[292] sprinkler (fixed systems) for 15.37% (558,834 ha) [293]; and sprinkler (automatically moved), 8.42% (306,272 ha)[294].

Irrigation techniques (area) by type of crop (MAGRAMA, 2015d) in 2015 were gravity irrigation, mainly for fodder crops (55%) and cereals (49%); sprinkler (fixed), mostly used for the irrigation of tubers (71%), leguminous (53%) and industrial (33%) and fodder crops (30%); sprinkler (automatically moved) for leguminous (27%), industrial (22%) and cereals (19%); and localised irrigation in vineyards (95%), olive groves (94%), citrus trees (81%), non-citrus trees and other woody crops (79%), vegetables and flowers (including those cultivated in greenhouse, 55%) (See Table 5.8).

[291] Regions with the highest % of irrigated land by this system: Andalusia (44%) Castile-La Mancha (17%), Comunidad Valenciana (11%) and Murcia (9%).

[292] Regions with the highest % of irrigated land by this system (there is a prevalence of arable crops): Aragón (19.59%), Andalucía (18.80%), Castile León (13.66%) and Catalonia (13.26%).

[293] Castile León (27%), Aragón (20%), Castile-La Mancha (18%) and Andalusia (13%).

[294] Mainly in Castile León (46%) and Castile-La Mancha (26%).

Table 5.8. Irrigated technique by type of crop

Crop type	Irrigated area	Gravity-fed/total area		Sprinkler (fixed)/total area		Sprinkler (automatically moved)/total area		Localised/total area	
	Ha	Ha	%	Ha	%	Ha	%	Ha	%
Cereals	**1,009,149**	**498,210**	**49**	**288,979**	**29**	**192,040**	**19**	**29,920**	**3**
Olive grove	748,708	40,903	5	1,053	0	65	0	706,687	94
Vineyard	365,767	7,787	2	10,409	3	492	0	34,080	95
Fruit trees (non-citrus)	290,677	56,797	20	4,941	2	66	0	228,872	79
Citrus trees	278,265	51,593	19	175	0	98	0	22,399	81
Fodder crops	247,784	136,389	55	74,384	30	36,463	15	548	0
industrial crops	208,844	52,210	25	68,248	33	45,318	22	43,068	21
Vegetables and flowers	204,649	30,970	15	47,816	23	12,466	6	113,398	55
Other crop areas	68,852	49,768	72	1,689	2	20	0	17,212	25
Tubers	42,338	6,029	14	30,254	71	2,969	7	3,085	7
Greenhouse (empty)	35,919	0	0	0	0	0	0	35,919	100
Leguminous	23,551	4,270	18	12,514	53	6,459	27	308	1
Nursery crop	16,319	3,362	21	931	6	465	3	11,561	71
Other woody crops	1,700	195	11	167	10	0	0	1338	79

Source: MAGRAMA, 2015d

Irrigation costs by source (e.g. groundwater, surface water, treated wastewater, desalination) per cubic meter of water

It is of paramount importance to highlight groundwater prices in areas of the country with high water scarcity since this is critical to understand some of the variables for further penetration of water reuse for agriculture. According to Custodio (2015) common prices for groundwater in SE Spain range between 0.3 and 0.5 €/m^3 (and can be higher depending on juncture and the cost of energy for pumping). In the Canary Islands (Gran Canaria and Tenerife Islands), usual prices are around 0.5 €/m^3 even if during peak demand they can go beyond 1€/m^3 (in Gran Canaria Island).

- Water prices (as a mix of surface, groundwater, desalinated, water from the Interbasin Tagus-Segura water transfer and reused water) for irrigation of vegetables in the Segura RBD (Martínez-Vicente et al., 2013 cited in Custodio, 2015) amount to 0.13-0.74 €/m^3 (0.15 €/m^3 in an average year). In the SE areas of the RBD: average price of water: 0.15 and 0.6 €/m^3 (0.15 €/m^3 in an average year); informal water markets: 0.15-0.60 €/m^3 (average price during drought period 2006-2009: 0.35 €/);
- Prices of irrigation water in the Guadalentín catchment (Garrido and Calatrava, 2009 cited in Custodio, 2015): 0.05 €/m^3 (surface), 0.127 €/m^3 (Tagus-Segura Transfer); 0,08 €/m^3 (reclaimed); 0.42-0.45 €/m^3 (desalinated) and 0.18 a 0.30 €/m^3 (groundwater);
- Prices of reclaimed wastewater in Campo de Cartagena: 0.15 €/m^3; price of desalinated water (Valdelentisco plant, close to Cartagena, Murcia): 0.36 €/m^3 (ADV, 2013 cited in Custodio, 2015);

- Tagus-Segura Transfer prices for irrigation during 1992-2001: 0.10 -0.30 €/m³ (and punctually, 0.75 €/m³) (PHS, 2013 cited in Custodio 2015);
- Groundwater abstraction average cost (irrigation): 0.21 €/m³ (under extreme conditions it may hit 0.74 €/m³) (Alcon et al., 2014); and
- Informal water trades for irrigation in Spain are a fact during drought events – water for irrigation paid at 0.6-0.7 €/m³; Water price (Tagus-Segura transfer – surface runoff): 0.12 €/m³; water price (lease contracts with irrigators from Tagus): 0.24 €/m³; water price in informal markets: 0.3-0.6 €/m³ (contingent on quality and scarcity) (Hernández-Mora & De Stefano, 2013).

In Spain, agriculture is the economic sector with the highest potential demand for reclaimed water use. So far, there are specific areas in the regions of Almeria and Murcia (SE of the country) suffering from acute water stress where highly productive and value horticulture crops are being cultivated that have already uptake reclaimed water as one of the main irrigation water sources. However challenges remain but in terms of low cost water from historic water rights hindering the use of other water sources such as reclaimed water (GWI, 2016).

5.4 Agricultural irrigation: proposal

Comparison of the draft JRC quality standards and Spanish regulation. Overview of scenarios

The Royal Decree 1620/2007 for Water Reuse differs from draft JRC report in the following basic issues:

Allowed uses: The prevailing Spanish Decree considers reclaimed water for other uses other than agricultural irrigation or aquifer recharge. This fact implies:

- If a binding or non-binding instrument at the EU-level is adopted, there would be an amount of reclaimed water (that produced for other purposes such as street cleaning in cities, vehicle washing, industrial uses or golf courses) that would not be subject to this instrument; and
- In such a case, a shift in percentages of produced reclaimed water by use could happen fostered by the adoption of any of the alternatives Ag.1 or Ag. 2, both if JRC standards are more stringent or permissive than the Spanish law.

Qualities: categories are defined by different criteria and so have different boundaries. The JRC report settles quality categories according to the level of additional treatment, including specific requirements for discharges in sensitive areas, while Spanish law establishes quality categories according to the use, linked to the results of the analytical control each category has to comply with. However, as both approaches respond to a "fit-for-purpose" one, there are some correspondences:

Table 5.9. Correspondences between quality categories of reclaimed water intended by its use (within agriculture irrigation), between Spanish and JRC standards

Quality definition by analytical controls - Spain	Quality category [1]	Quality definition by use and treatment - JRC
	A: Very High Quality	- Food crops to be eaten in raw status *(Advanced treatment or secondary treatment – filtration and disinfection)*
2.1. Irrigation systems with direct contact between reclaimed water and edible parts of crops to be eaten raw	**B: High Quality**	- Processed food crops to be eaten after a treatment process *(Secondary treatment with > 25 days lagoon detention time and disinfection)*

Quality definition by analytical controls - Spain	Quality category [1]	Quality definition by use and treatment - JRC
		- Processed food crops to be eaten after a treatment process *(Secondary treatment with disinfection or without additional disinfection)*
2.2. Irrigation crops to be eaten by humans not raw but after an industrial treatment process (irrigation methods do not prevent direct contact of reclaimed water with edible parts of the crop); or pastures (for milk or meat producing livestock)	**C: Good Quality**	- Crops which are not intended for human consumption (e.g. pastures, forage, fibre, ornamental, seed, forest, and turf crops) *(Secondary treatment without additional disinfection)*
2.3. Woody crops with fruit for human consumption whereby reclaimed water is not allowed to be in direct contact with fruits; or ornamental flowers/nurseries and greenhouses with no direct contact between reclaimed water and the products; or non-edible industrial crops, nurseries, fodder (silo), cereals and oilseeds).	**D: Medium Quality**	

[1]: Quality matchings have been addressed following MARM (2010b)

Quality parameters: quality categories represent the basis to find out similarities and discrepancies in parameter maximum levels required for the same group of crops between both standards:

- The number of colony-forming units of *Escherichia coli* is a parameter considered in both regulations, with maximum levels proposed in the JRC draft for categories A, B and C matching the Acceptance Maximum Values established in the Spanish Decree for categories 2.1, 2.2 and 2.3 respectively;
- Total suspended solids concentration is a parameter considered also in both standards. The maximum level of TSS settled as 10 mg/l in the JRC draft for quality A (Very High Quality), together with turbidity (again settled twice as stringent as in Spanish regulation for this quality) makes the JRC proposal more restrictive at these specific parameters than the Spanish Decree, preventing thus the matching of groups of crops 2.1, 2.2 and 2.3 with categories A, B and C, but with C, D and E respectively (Table 5.8);
- Spanish regulation considers intestinal nematodes for each of the qualities of water reused for agricultural irrigation, whereas the JRC proposal does not. It is required to control for at least *Ancylostoma*, *Trichuris* and *Ascaris* genera;
- Levels of organic substances: Spanish Decree does not address specifically for BOD_5 levels, as does the JRC proposal. However, organic substances and turbidity are correlated and since the Decree observes the compliance of the correspondent discharge authorisation –which in turn should require a control of BOD_5 levels- this discrepancy does not seem to represent a significant issue to consider;
- Bacteriological parameters are considered to be monitored within the Spanish regulation (*Legionella* spp, *Salmonella* or both, depending on the quality group, but only for risk management in the draft JRC proposal;
- Other chemical characteristics are required to be addressed within the Spanish Decree, while the JRC proposal only mentions them as part of the guideline to interpret water quality for irrigation (with reference to FAO, 1985). These are coincident parameters: conductivity, SAR, and concentration of the following elements: Boron, Arsenic, Beryllium, Cadmium, Cobalt, Chromium, Copper, Manganese, Molybdenum, Nickel, Selenium and Vanadium;

- For the specific case of irrigation of pastures for meat producing livestock, helminth (*Taenia saginata* and *T. solium*) presence is considered to be control for within Spanish regulation, but is not considered in JRC proposal; and
- The presence of hazardous substances has to be limited as is required to comply with Environmental Quality Standards within the Spanish Decree, while JRC proposal does not address this issue

Monitoring: The JRC states quality parameters should be monitored, but as far as the proposal for guidance is still in draft form, it is unclear which parameters wlll be those required for monitoring purposes and which are the established frequencies for controls. In contrast, Spanish regulation details monitoring schedule for each parameter as stipulated risk management measures, with frequencies that range weekly (TSS, turbidity, *E.coli*) to monthly (bacteria and chemical characteristics).

General comparison:

- Overall, Spanish regulation is more restrictive than JRC draft in terms of the completeness of what it has to be controlled for (number of parameters, with some of them not considered within JRC proposal (nematodes or helminths presence) and others only exposed to interpret quality categories (chemical parameters) or within the risk assessment scheme (bacteriological parameters). Spanish regulation contains also technical requirements of monitoring programme, including frequencies of sampling and laboratory standard methods. In contrast, it is still unclear which parameters are going to be required for monitoring purposes in JRC guidance and it does not provide specificities about monitoring. Nevertheless, some of the maximum levels are more stringent in the JRC proposal than in the Spanish regulation, which explains why similar types of crops would reach higher values of quality in that scenario;
- JRC proposal incorporates information about minimum buffer zones between irrigation areas and the nearest public access point, whereas Spanish Decree does not address this issue; and
- JRC proposal includes the “restriction on use” criteria for water quality allocation (as in FAO, 1985), which implies that a 20% of change above or below the guideline value would have little significance if considered in proper perspective with other factors affecting yield. Management skill of the water user could alter the way in which the divisions are interpreted for a particular application.

Non-binding standards for water reuse

Given that Spain has been applying its specific regulation for water reuse since 2007, there already is advanced knowledge and a wealth of experiences both among users and authorities. In such a context, whether non-binding EU standards for water reuse would have any effect in the country or not would actually depend on political will to foster the adoption of a new scheme, with those technical implications that came up from the above analysis.

An important issue to consider in this scenario is whether Spanish authorities would encourage users to adopt EU recommendations only in those maximum levels that are more stringent in the JRC proposal, lowering them, while keeping the rest of restrictions already in the Spanish regulation, once users are already used to them. This option would be environmentally beneficial, but it might entail a handicap for Spanish operators, that would be encouraged to make an additional effort (technology, investment, monitoring) while keeping in a very complete programme of monitoring (more comprehensive than in other MS). Additional costs of producing reclaimed water for agricultural irrigation might be transferred to end users through water tariffs. However, water users might see adherence to EU non-binding standards as a further safety guarantee (i.e. consumers might then be more willing to buy fruit and vegetables to be eaten with no treatment, even if irrigated with recycled water).

On the other hand, if EU standards would be not binding, Spain might decide to keep its own standards in place, to avoid administrative burden and additional compliance costs for water reuse companies. Yet this option would have implications in terms of the competitiveness of products irrigated with reclaimed lower quality water (with higher thresholds for TSS and turbidity parameters) in EU markets. The alternative would be to progressively adapt Spanish regulation to the EU recommendations, which links directly to the analysis of the binding-standards.

In other words, Spain would be in two minds between adapting to the whole JRC proposal as a recommendation (then focusing on less but more stringent parameters –TSS, turbidity, incorporating BOD_5 thresholds) or applying a more complete scheme that nevertheless yields lower quality classification of reclaimed water for similar group of crops compared to other MS.

Binding standards for water reuse

This builds on the assumption made in the previous scenario, to analyse the alternative of adopting a binding standard for reclaimed water for agricultural irrigation, Spain would adjust existing standards to the draft JRC proposal, lowering the thresholds for TSS and turbidity and incorporating BOD_5 acceptance maximum levels. For the purpose of the IA exercise, and given that operators have been subjected to standards since 2007, it can be assumed that the rest of the requirements would be maintained in the Spanish regulation (as they are today).

Regarding emphasis on risk management within the JRC proposal, adopting the concept of multiple barriers – preventive measures on wastewater treatment and farm management might lead to additional costs as well. However, prevailing regulation in Spain already considers risk management within the application of each new authorisation (the project is required to specify and develop detailed risk management measures), which needs to be informed by RBD authorities.

Furthermore, there is a need to explore the following issue:

- To what extent the adoption of more stringent values (TSS, turbidity and BOD5 maximum allowed levels for each quality) would be generally adopted by the already operating treatment plants or the projected ones in a cost-effective way. Operators would need to develop treatment technologies and face higher costs of treatment, accordingly. However, the change in monitoring costs cannot be evaluated until JRC proposal includes specificities of monitoring programmes. Nevertheless, given that Spanish regulation already requires an intensive monitoring scheme, it is likely that it would not represent an additional effort (and cost) in this regard.

how much volume of enough quality water would be available under this binding scenario to meet the demand of agricultural irrigation, particularly in those areas where water exploitation, crop irrigation needs and water stress is higher, to address water security;

5.5 Agricultural irrigation: assessment of key impacts

Table 5.10. Assessment of impacts for policy options Ag.1 and Ag.2

Economic impacts		
	Non-binding standards for water reuse	**Binding standards for water reuse**
Functioning of the internal market and competition	Relevant impacts on competitiveness might be expected if operators are encouraged to upgrade their treatment units to comply with lower thresholds of quality parameters (TSS, turbidity and BOD_5) while keeping in a more intensive monitoring programme than in other MS. However, it is still unclear whether new monitoring requirements (especially frequency) will be stricter or easier to be attained by water operators	No relevant impacts are expected –as the regulations would equally apply to all water reclamation operators.

Economic impacts		
Operating costs and conduct of business/Small and Medium Enterprises.	Existing reclamation plants would be encouraged to upgrade their treatment units to comply with lower thresholds of quality parameters (TSS, turbidity and BOD_5), and this would imply additional costs. However, it is not possible to estimate these costs given the large range of costs showed for different technologies currently in use and some lack of data. The current Spanish regulation already requires operators to comply with a complete monitoring programme. This policy option includes stricter limits on some parameters, and it is assumed that other requirements will not change (e.g. monitoring protocols, requirements for pipelines, etc.). Therefore, it can be assumed that this policy option might even be (slightly) more constraining for the development of the water reuse sector for irrigation purposes in Spain.	Existing reclamation plants would need to upgrade their treatment units to comply with lower thresholds of quality parameters (TSS, turbidity and BOD_5), as well as additional quality standards (TSS, turbidity and BOD_5); this would imply additional costs. However, it is not possible to estimate a magnitude of these costs given the large range of costs showed for different technologies currently in use and several data gaps. Nevertheless, these costs might be higher as compared to the non-binding option. Whether new monitoring requirements (especially frequency) and requirements for the pipeline network will be stricter or easier to be attained by water operators is still to be defined.
Administrative burdens on businesses	The upgrade of treatment units to adapt them to higher quality standards might require additional effort applying for complementary authorisations, with additional administrative costs for water reclamation companies. No additional monitoring costs are expected, as the same parameters will need to be monitored, and with the same frequency –as compared to the current situation.	The upgrade of treatment units to adapt them to higher quality standards would require additional effort applying for complementary authorisations, with additional administrative costs for water reclamation companies. Whether new monitoring requirements (especially frequency) will be stricter or easier to be attained by water operators is still to be defined.
Public authorities	No significant impact is expected on budgets of public authorities. Complementary authorisations might involve some administrative costs for public authorities in charge of issuing permits. There might be additional costs of explaining operators the new scenario.	No significant impact is expected on budgets of public authorities. Complementary authorisations would involve some administrative costs for public authorities in charge of issuing permits. There would be additional costs of explaining operators the new scenario.
Innovation and research	Encouraging the adoption of stricter limits for some quality parameters might promote research on innovative treatment technologies.	The introduction of stricter limits for some quality parameters might promote research on innovative treatment technologies.
Consumers and households	Additional costs for water reclamation plants might also imply increased costs for water users. Additional costs might be charged on farmers: however, an increase in irrigation water price might provide a negative incentive to the use of recycled water in irrigation. Alternatively, as it often happens, additional costs might recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with available data and information. On the other hand, stricter quality limits might increase consumer protection and acceptance.	Additional costs for water reclamation plants might also imply increased costs for water users. Additional costs might be charged on farmers: however, an increase in irrigation water price might provide a negative incentive to the use of recycled water in irrigation. Alternatively, as it often happens, additional costs might recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with available data and information. On the other hand, adjusting national standards to EU standards might have a positive impact on the public perception of using recycled water for irrigation, as it might serve as a further guarantee of the overall safety of the system. Stricter quality limits might increase consumer protection and acceptance.

Social impacts	Non-binding standards for water reuse	Binding standards for water reuse
Employment and labour markets	In case the policy option will promote research on innovative technologies, some jobs might be created, depending on the level of adoption of the recommendations.	In case the policy option will promote research on innovative technologies, some jobs might be created. It is not possible to quantify this impact, especially because, at this stage, it is not possible to infer whether the draft JRC proposal will promote or further constrain the development of water recycling for irrigation purposes.
Governance, participation, good administration, access to justice, media and ethics	Stricter quality limits might increase consumer protection.	Adjusting national standards to the draft JRC proposal might have a positive impact on the public perception of using recycled water for irrigation, as it might serve as a further guarantee of the overall safety of the system. Stricter quality limits might increase consumer protection.
Public health and safety	The current Spanish regulation is already protecting the population against the possible risks. Nevertheless, this policy option proposes even stricter quality standards for recycled water, so, depending on the level of adoption, it might be expected to increase the level of health protection of these practices.	The current Spanish regulation is already protecting the population against the possible risks. Nevertheless, this policy option proposes even stricter quality standards for recycled water, so it is expected to increase the level of health protection of these practices.

Environmental impacts	Non-binding standards for water reuse	Binding standards for water reuse
Water quality and resources	Overall, water recycling decreases quantitative pressures on freshwater resources, including groundwater. However, it does not seem that this policy option will promote an expansion of water recycling practices in the country, so no significant changes on current qualitative pressures on freshwater resources can be expected.	Overall, water recycling decreases quantitative pressures on freshwater resources, including groundwater. At this stage, it is unclear whether the draft JRC proposal will further constrain or promote water reuse practices in the country, so it is not possible to infer whether quantitative pressures on freshwater resources will decrease. If it does, significant impacts are expected especially in those RBD where there is a need to improve water security (e.g. SE of Spain or islands).
Renewable or non renewable resources	No significant impacts are expected.	No significant impacts are expected.
The environmental consequences of firms and consumers	Irrigating crops with recycled water is in principle an environmental-friendly practice, as it spares freshwater resources which can be diverted to other uses (e.g. domestic) or to the environment. However, it does not seem that this policy option will promote an expansion of water recycling practices in the country, so no significant impact is expected on current levels of agricultural production with recycled water.	Irrigating crops with recycled water is in principle an environmental-friendly practice, as it spares freshwater resources which can be diverted to other uses (e.g. domestic) or to the environment. At this stage, it is unclear whether the draft JRC proposal will further constrain or promote water reuse practices in the country, so it is not possible to figure out the potential impact on current levels of agricultural production with recycled water.

Table 5.11 Synthesis table of impact assessment for agriculture irrigation

	Non-binding standards for water reuse	Binding standards for water reuse
Overall economic impact	**-/--**	**0/-**
Functioning of the internal market and competition	- -	0
Operating costs and conduct of business/Small and Medium Enterprises	- -	-
Administrative burdens on businesses	-	- -
Public authorities	0/-	0

	Non-binding standards for water reuse	Binding standards for water reuse
Innovation and research	+	+
Consumers and households	-	-
Overall social impact	**0/+**	**+**
Employment and labour markets	0	0
Governance, participation, good administration, access to justice, media and ethics	0/+	+
Public health and safety	0/+	++
Overall environmental impact	**0**	**0/+**
Water quality and resources	0	0/+
Renewable or non renewable resources	0	0
The environmental consequences of firms and consumers	0	0/+

++ Significant positive impact	**- -** Significant negative impact	**0** No relevant impact
+ Mild positive impact	**-** Mild negative impact	

5.6 Aquifer recharge: baseline

Groundwater resources

According to the last implementation report of the WFD (EC, 2015), the number of delineated groundwater bodies (GWB) in Spain is 748, with an average size (De Stefano et al., 2013b) of 482 km2 and a total area of more than 355,564 km2. De Stefano et al. (2015) estimated that groundwater abstraction is around 6,125-6,925 hm3/yr. i.e., around 22% of the total water demand. Agriculture is the main groundwater user (70-72%), followed by domestic supply (23-22%) and industry (6-5%) and, to a lesser extent, recreational uses (0.4%). The chemical status of GWB (% by number of bodies) was good for 66.0%, poor for 32.9%, unknown for 1.1%. On quantitative grounds, the status was good for almost three fourths (71.3%), poor for 27.3% and unknown for 1.5% (EC, 2015).

Aquifer recharge

See section 5.2 (“Wastewater collection and treatment” – “National regulations and guidance”) with details on Decree 1620/2007 (BOE, 2007), setting up the legal framework for reusing treated wastewater for irrigation and water recharge.

Estimates from the DINA-MAR Research Project (Escalante, 2014a) show that managed aquifer recharge (MAR) in Spain hits 380 hm^3/year[295]. According to the DEMEAU Project (Hannappel et al., 2014), 25 out of the 270 European known MAR sites (9%) are in Spain, most of them (López-Vera, 2012) in Mediterranean regions. At European scale, Spain is the European country where MAR for irrigation is more common. Environmental uses (e.g. to restore the hydraulic gradient to mitigate seawater intrusion at the Llobregat aquifer in Barcelona – by means of injection wells/ infiltration through infiltration ponds, and Marbella) are also common (as in other European countries such as Germany and The Netherlands). In Spain, in practice all MAR schemes are implemented in fluvial deposits. Main types MAR are Aquifer Storage and Recovery (ASR) and Aquifer Storage Transfer and Recovery (ASTR) and infiltration ponds, followed by flooding and, to a lesser extent, by others such as pits and excess irrigation, riverbed scarification, and ditch and furrow.

[295] Comparison with other water management techniques used in the country (Escalante, 2014): 53000 hm^3 stored in reservoirs; around 6000 hm^3/yr, groundwater use; water reuse and “recycling”, around 450 h3/yr); desalination: around 547,5 hm^3/yr (around 1000 desalination plants).

There is no information available within the second cycle of RBMPs about specific volumes of treated wastewater used for aquifer recharge.

The mean investment cost ratio (€/m^3) differs according to the implemented MAR technique. Escalante (2014a: 2014b) provides examples on the basis of implemented projects: 9.75 €/m^3 for ponds; 0.80 €/m^3 for dams; 0.23–0.58 €/m^3 for deep boreholes (deep injection)[296]; 0.36 €/m^3 for medium-deep boreholes and 0.21 €/m^3 for surface MAR facilities (ponds, channels). 16% of the analysed area in the country (Iberian Peninsula and Balearic Islands, Canary Islands excluded: *circa* 500,000 km2) has the potential for being used for MAR (i.e. 134,000 hm^3, i.e. 2 hm^3/km^2).

5.7 Aquifer recharge: proposal

Comparison of the draft JRC quality standards and Spanish regulation. Overview of scenarios

Royal Decree 1620/2007 for Water Reuse differs from draft JRC report in the following basic issues:

Allowed uses: The Spanish Decree does not consider reclaimed water for recharging aquifers that are going to be used as a potable water source. In any case, it is recommended 1-year retention time of reclaimed water into the water table before being extracted again (MAGRAMA 2010b)

Qualities: given the previous consideration, issues related to minimum requirements of the Drinking Water Directive do not apply to Spanish case study regarding the JRC proposal. In the case of reclaimed water to recharge aquifers for a non-potable use, compliance with Groundwater Directive 2006/118/EC is required. However, Spanish Decree establishes two quality categories for this type of reclaimed water: 5.1- reclaimed water to recharge aquifers by surface infiltration or indirect recharge, and 5.2- reclaimed water to recharge aquifers by direct injection (direct recharge).

Quality parameters: regarding the reference to GWD within JRC proposal, nitrates and active substances in pesticides need to be control for to ensure enough quality and a “Good groundwater chemical status” as in Annex I of GWD. Nitrates are considered as well within the Spanish Decree, establishing Acceptable Maximum Values for nitrates, although no expressly mention to pesticides is given. Additionally, Spanish regulation maintains the requirement to control parameters as in other uses (nematodes, *E.coli*, TSS and turbidity). As a result, water quality is established as C: Good quality for indirect recharge (5.1) and as A: Very Good Quality for direct recharge (5.2).

Monitoring: It is still unclear what would be the monitoring requirements (parameters and frequency) for these uses in the JRC proposal. In any case they must comply with the GWD. In contrast, Spanish regulation details a monitoring schedule for each parameter as stipulated risk management measures, with frequencies that range daily (turbidity) to weekly (nematodes, TSS, nitrates and other).

Non-binding standards for water reuse

Again, Spain has been applying its specific regulation for water reuse since 2007, so there already are experiences in place. A fundamental issue for the analysis is that Spanish regulation does not consider reclaimed water to recharge aquifers with a potable use. For non-potable use aquifers and given that there is still limited information about technical requirements for monitoring within JRC proposal, adoption of recommendations at the EU level would imply to encourage operators to incorporate techniques to control for active substances in pesticides.

As in the analysis for agricultural irrigation, whether non-binding EU standards for water reuse would have any effect in the country or not would depend on political will to foster the adoption of a new scheme, taking into account technical implications and related costs. Moreover, it is not expected that non-binding standards for water reuse provided at European level will have any significant impact in the country. In the best case the promotion of non-binding standards might re-start discussions on the issue.

[296] For flows between 50 abd 80 l/s) average cost value: first value of the rage refers to 50 m and second to 500 m. Tertiary treatment was not considered.

Binding standards for water reuse

In this scenario, Spain would adjust existing standards to the draft JRC proposal, incorporating active substances in pesticides as a control parameter. For the purpose of the IA exercise, and given that operators have been subjected to standards since 2007, it can be assumed that the rest of the requirements would be maintained in the Spanish regulation (as they are today).

Legally binding standards at European level would probably provide more transparency around the groundwater overexploitation and possibilities of recharge.

5.8 Aquifer recharge: impact assessment

Table 5.12. Assessment of impacts for policy options Aq.1 and Aq. 2

Economic impacts	Non-binding standards for water reuse	Binding standards for water reuse
Operating costs and conduct of business/Small and Medium Enterprises.	Existing reclamation plants would be encouraged to upgrade their monitoring procedures to control for active substances in pesticides, and this would imply additional costs. However, it is not possible to estimate a magnitude of these costs given the large range of costs showed for different technologies currently in use. The current Spanish regulation already requires operators to comply with a complete monitoring programme.	Existing reclamation plants would need to upgrade their monitoring procedures to control for active substances in pesticides; this would imply additional costs. However, it is not possible to estimate a magnitude of these costs given the large range of costs showed for different technologies currently in use. Nevertheless, these costs might be higher as compared to the non-binding option. Whether new monitoring requirements (especially frequency) will be stricter or easier to be attained by water operators is still to be defined.
Administrative burdens on businesses	No significant impact is expected due to the voluntary incorporation of an additional control parameter (active substances in pesticides) as compared to the current situation.	No significant impact is expected due to the incorporation of an additional control parameter (active substances in pesticides) as compared to the current situation.
Public authorities	No significant impact is expected on budgets of public authorities. There might be additional costs of explaining operators the new scenario.	No significant impact is expected on budgets of public authorities. There would be additional costs of explaining operators the new scenario.
Innovation and research	No significant impact is expected due to the voluntary incorporation of an additional control parameter (active substances in pesticides) as compared to the current situation.	No significant impact is expected due to the incorporation of an additional control parameter (active substances in pesticides) as compared to the current situation.
Consumers and households	Additional costs for water reclamation plants might imply increased costs for water users. Alternatively, as it often happens, additional costs might recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with available data and information.	Additional costs for water reclamation plants would imply increased costs for water users. Alternatively, as it often happens, additional costs might recovered through cross-subsidization mechanisms, i.e. prices of recycled water are kept low, to provide an incentive for its use, and the remaining share of production costs are covered by other users (often domestic users). However, estimating a possible magnitude of this impact, and on whom, is impossible with available data and information. On the other hand, enhancing water security will have positive economic effects on end users.

Social impacts	Non-binding standards for water reuse	Binding standards for water reuse
Employment and labour markets	No significant impact is expected due to the voluntary incorporation of an additional control parameter (active substances in pesticides) as compared to the current situation.	No significant impact is expected due to the voluntary incorporation of an additional control parameter (active substances in pesticides) as compared to the current situation.
Governance, participation, good administration, access to justice, media and ethics	Enhanced water security would have a positive impact, although it depends on whether the adoption of recommendations at the EU-level would promote or not the development of aquifer recharge by reclaimed water.	Enhanced water security would have a positive impact.
Public health and safety	The current Spanish regulation is already protecting the population against the possible risks.	The current Spanish regulation is already protecting the population against the possible risks.

Environmental impacts	Non-binding standards for water reuse	Binding standards for water reuse
Water quality and resources	Although it does not seem that this policy option will promote an expansion of water recycling practices in the country, the incorporation of an additional control parameter (active substances in pesticides) will have a significant positive impact. The magnitude will depend on the level of adoption of the recommendations	The mandatory incorporation of an additional control parameter (active substances in pesticides) will have a significant positive impact, especially in those RBD where there is a need to improve water security (e.g. SE of Spain or islands).
Renewable or non renewable resources	No significant impacts are expected.	No significant impacts are expected.
The environmental consequences of firms and consumers	No significant impacts are expected.	The positive impact in aquifer water quality would have positive consequences for all

Table 5.13 Synthesis table of impact assessment for aquifer recharge

	Non-binding standards for water reuse	Binding standards for water reuse
Overall economic impact	**0/-**	**0/-**
Operating costs and conduct of business/Small and Medium Enterprises	0	0
Administrative burdens on businesses	0	0
Public authorities	0	0
Innovation and research	0	0
Consumers and households	0/-	0/-
Overall social impact	**0**	**+**
Employment and labour markets	0	0
Governance, participation, good administration, access to justice, media and ethics	+	++
Public health and safety	0	0
Overall environmental impact	**0/+**	**+**
Water quality and resources	+	++
Renewable or non-renewable resources	0	0

The environmental consequences of firms and consumers	0	+

++ Significant positive impact

- - Significant negative impact

0 No relevant impact

+ Mild positive impact

- Mild negative impact

6. Romania

6.1 Romania: problem definition in a nutshell

Romania's water resources are relatively poor and unevenly distributed geographically. In 2014, total water resources (theoretical resources) amount to 134.6 billion m^3, including the surface waters, respectively rivers, lakes, the Danube River and groundwater, of which the usable resource, according to the degree of arrangement of hydrographic basins, is about 40 billion m^3. Groundwater is not overexploited in Romania. Continuing the trend of the last years, data in 2014 showed that surface water abstraction accounted for around 10 times the volume of water abstracted from groundwater resources.

Table 6.1 Potential and technically usable water resources in 2014

Water source Characterization indicator	**Total Mm^3**
A. Inner streams	
1. Theoretical resource	40.000.000
2. Existing resource according to the facility degree of the hydrographic basins*	13.679.121
3. The water demand of the utilities, according to the operational intake capacities	3.530.694
B. Danube (directly)	
1. Theoretical resource (in the section where it enters the country) **	85.000.000
2. Usable resource in the current facility regime	20.000.000
3. The water demand of the utilities, according to the operational intake capacities ***	3.031.891
C. Underground	
1. Theoretical resource, of which:	9.600.000
-ground waters	4.700.000
-internal waters	4.900.000
2. Usable resource	4.667.639
3. The water demand of the utilities, according to the operational intake capacities	646.679
D. Black Sea	
The water demand of the utilities, according to the operational intake capacities	8902
Total resources	
1. Theoretical resource	134.600.000
2. Existing resource according to degree of the hydrographic basins	38.346.760
3. The water demand of the utilities, according to the operational intake capacities	7.218.166

Source: Romanian Waters" National Administration
Note *Contains also the lakes from the seaside, as well as the resource ensured by direct external reuse along the river.
** ½ of the average annual discharge, into the country
*** including volumes transferred into the Seaside Basin

The water demand in Romania decreased in 2014 to 7.21 billion m^3, representing less than half that in 1990 (20.4 billion m^3 of water). Since 2001 the water demand decreased by almost half compared to 1990.

The water demand in Romania has decreased by 12.92 billion m^3 compared to the year 1990, respectively from 20.4 billion m^3 of water (as it was in 1990) to 7.48 billion m^3 in 2013. Between 1990-2013 there has been a serious decrease of the water demand in agriculture, by 7.69 billion m^3 of water. As regarding the water use, the Romanian waters resources infrastructure has the capacity to supply at least three times more than the current demand.

Broken down by three categories of users (population, industry and agriculture), the most dramatic decrease in the volume of consumed water was recorded in the agricultural sector, which dropped from 9,1 billion m^3 of water (in 1990) to 1.08 billion m^3 of water (in 2014). The industrial sector consumed 4.17 billion m^3 in 2014. The volume of water consumed for the population decreased by 1.2 billion m^3 compared to 1990 (from 2,22 billion m^3 in 1990 to 1,02 billion m^3 of water consumed in 2014).[297]

Romania is relatively poor in water resources but it will not be covered by the risk of depletion of water resources, with an estimate of the amount of water available annually of at least 1.7 million litres of water / capita, ranking it 13th in Europe. According to the Water Exploitation Index, the last indicator presented in

[297] Statistics conducted according to data provided by the National Administration "Romanian Waters"

2013 was 15.2, which is below the warning threshold of 20%.[298] Some rivers basins however (Jiu, Arges-Vedea, Buzau-Ialomita and Prut-Barlad) have a water exploitation index 23,15 and 43,33%[299].

The balance between water availability in 2014 and the expected trends for water demand shows however no deficit at state level or in the 11 sub-basins; there are however some river sections with deficits in the Prut – Bârlad and Dobrogea – Sea-Cost basins that should be carefully considered in the future[300]. Romania manifests a clear tendency to intensify and extend the drought and desertification phenomenon because of natural, but also because of anthropic reasons (deforestation, destruction of the irrigation system, etc. Of all 14.7 million hectares of arable land, approx. 7 million hectares of land (48% from the total) are affected by drought, during long periods and on consecutive years. Currently, the desertification phenomenon manifests on approx. 350 000 de hectares, mainly in the south of Romania[301].

Romania has an increased frequency of floods, especially in the spring due to the snow melting and the blocking of the rivers with blocks of ice, as well as in the summer due to the heavy rains when the river flows increase above the normal limit. In the last 16 years, the frequency of floods has increased, being a consequence of the climate changes, illegal forests cutting but also due to the insufficient infrastructure for floods prevention. In accordance with the latest European and national statistics, their frequency and intensity is increasing.

Information on water reuse potential

Currently there is no treated wastewater reuse being practiced in Romania, neither in the irrigation system, nor for aquifers recharge. Wastewater reuse in irrigation was launched experimentally as part of research projects, but it is not a mainstream practice. In regards to aquifer recharge, this is currently a prohibited practice, as the Waters Law no. 107/1996 with further amendments prohibits injections of wastewater into groundwater.

Although there is potential for water reuse, as Romania is a country relatively poor in water resources, there are several factors that, in the short and medium term, might slow down the development of these practices in the country. The most important factors are the following:

- In the last 25 years, water consumption decreased considerably, due to industry and agriculture collapsing along with the fall of the communist regime. Although Romania is confronted with seasonal droughts in some regions, water shortage is not so strong as to put pressure for seriously considering treated wastewater reuse;
- Use of irrigations has not been a common practice in the post-communist years, due to the price of water being too high for the farmers. Use of irrigations has fallen down from approx. 2 million hectares being irrigated in the communist era to 100.000 hectares in 2015. Although the number of irrigated land is expected to increase in the following years, it will most likely be a slow process. In this process, eventual increase in the price of water, due to investments needed in further water treatment will most likely not be encountered positively;
- Contacted to express their point of view on these matters, the representatives of the Ministry of Environment, Waters and Forests expressed some concern in regard to the use of treated wastewater in irrigations, due to the safety / human health issues it might provoke. The representatives believe that the priorities of the sector lie with the reduction of specific water quantities used in industry and agriculture by reducing the losses, the application of modern technology (spray and drip irrigation, sub-irrigation) and the reuse of wastewater in technological processes that do no necessitate a certain water quality; and
- Currently, most aquifers recharge naturally and they do not need to be recharged artificially, let alone with treated wastewater. So far, on a general level, use of treated wastewater in aquifer

[298] Eurostat, http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tsdnr310&plugin=1
[299] National Development Plan for River Basins in Romania 2013, National Administration Romanian Waters
[300] Report on the State of Environment 2015 – National Environmental Protection Agency, according to data offered by the National Administration Romanian Waters
[301] National Strategy regarding the reduction of drought effects, prevention and mitigation of land degradation and desertification, on short, medium and long term, 2008

recharge does not constitute a priority for the officials at the Ministry of Environment and Forests. There is an interest however in the indirect discharge of wastewater in groundwater, in locations where there are no surface waters within reasonable distance (this is the case of many localities in Dobrogea). Interest exists also in the development of standards that would detail the quality of wastewater that would be discharged in biological ponds which allow the infiltration of these waters into groundwater. In the future, the picture might change due to increased droughts brought by climate change and economic growth, which will generate more water consumption.

In conclusion, the estimates are that the potential of reused wastewater in Romania, although existent, will only be possible to be exploited in a medium to long time frame.

6.2 Wastewater collection and treatment

Annual volumes of wastewater generated, collected and treated

Table 6.2 presents the volumes of generated wastewater in Romania since 2009, it shows that between 2009 and 2013 the volumes of generated wastewater more than halved.

Table 6.2 Volumes of generated wastewater in Romania since 2009 (million m^3)

2009	2010	2011	2012	2013
5124.9	4877.5	5626.6	4982.9	2007.2

Source: Eurostat, *http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ww_genv&lang=en*

The table below shows that although there is a continuous effort towards investing in adequate treatment of wastewater, there are is still a significant percentage of wastewater being treated inadequately or not treated at all. Further investments in wastewater infrastructure are necessary and will be conducted in the following years.

Table 6.3 Volumes of wastewater evacuated at national level in natural receptors during the period 2011 – 2014 (thousand m^3)

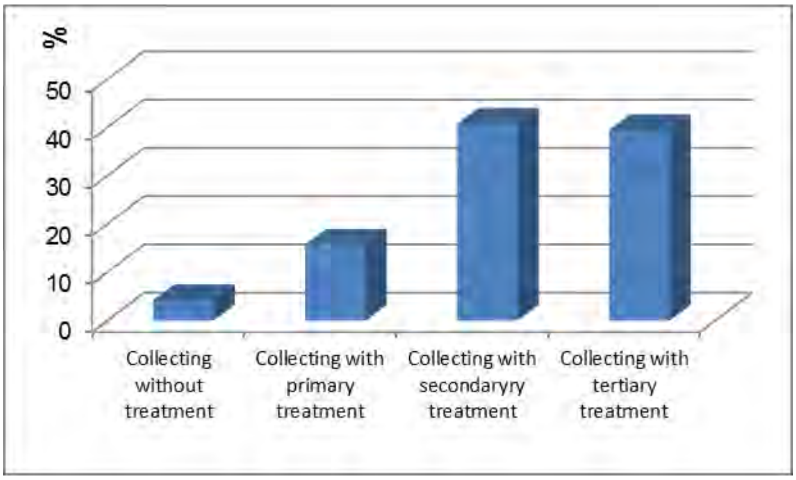
Year	Total evacuated	No treatment needed	Not treated	Treated	
				Inadequate treatment	Adequate treatment
2011	5303988,13	3005935,92	826829,43	898928,21	572294,58
2012	4985141,14	2787700,63	665843,36	881306,72	650290,43
2013	4872641,26	2911880,03	413948,93	433497,30	1113315,00
2014	4784719,64	2845917,86	357441,65	541982,06	1039378,07

Source: National Administration “Romanian Waters”, Synthesis of water quality in Romania

Treated effluent quality by volume and treatment level (primary, secondary and tertiary)

In 2013, 9,300,460 inhabitants had their houses connected to sewage systems, this represents 46.5 % of Romania’s population. In regards to wastewater treatment, the population with houses connected to collection systems that are provided with treatment stations was of 8,883,583 persons, representing 44.4% of the country’s population. The population’s rates of connection to wastewater collection and treatment systems, differentiated on treatment levels, are presented in Table 6.4.

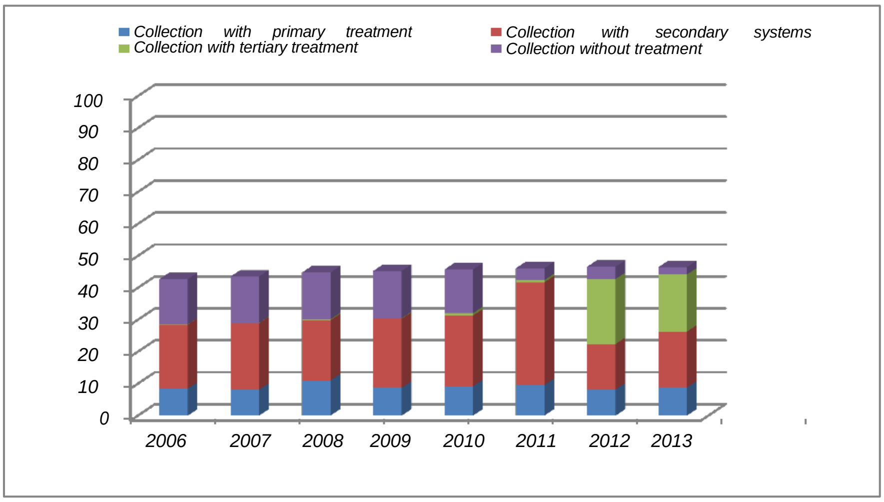
Table 6.4 Population connected to the wastewater collection and treatment systems (%)



Source: National Institute of Statistics, www.insse.ro

The evolution of the population's connection (Table 6.5) to the wastewater collection and treatment systems depending on the type of applied treatment process indicates an increase in the number of inhabitants that benefit from wastewater services, which is a consequence of extending and building appropriate infrastructure.

Table 6.5 Population connected to the wastewater collection and treatment systems



Source: National Institute of Statistics, www.insse.ro

Since 1990, the proportion of collecting systems with tertiary treatments increased significantly, as shown in Table 6.6. Tertiary treatment efficiently removes organic matters, as well as compounds with phosphorus and nitrogen.

Table 6.6 Population connected to at least secondary wastewater treatment, 1990–2013 (% of total)

2005	2010	2011	2012	2013
17	22	31	33	36

Source: Eurostat, Energy, transport and environment indicators 2015 edition

Wastewater treatment costs

There is no publicly available information on wastewater treatment costs associated with different treatment levels.

Relevant legislation

While there is no specific legislation that refers to reuse of treated wastewater in agricultural irrigation, there is some general legislation referring to water reuse. The amended technical norms from 28 February 2002 regarding collection, treatment and evacuation of urban wastewater, NTPA-011, which is annex to the Government Decision no. 188/20.03.2002 approving norms for discharging into aquatic environment of used waters, subsequently amended and completed, states in article 6 that treated wastewater will be reused anytime this is possible, with the permit of the competent authorities, depending on its origin and the field of use. Reuse of these waters must be done with the aim of reducing the negative effects on environment to a minimum.

Law no. 241/2006 regarding the water supply and sewage services also states that water operators shall ensure the limitation of drinking water quantities distributed in public networks, used in industrial processes, and the reduction of specific consumptions trough recirculation and reuse.

Regarding the use of treated wastewater in aquifer recharge, the amended Waters Law no. 107/1996 prohibits injections of wastewater into groundwater. In this respect, in Romania the deep aquifers are considered as strategic water resources which is protected and used only for drinking water supply purposes. The same law states however that the right to use surface and groundwater is established through the water management permit. This right includes, among other things, the right to discharge wastewaters. Order no. 662/2006 which approves the “Procedure and competences to issues water management notifications and permits”, art. 8, Annex 1a - “The list of works and categories of activities placed on waters or which are connected with waters, for which a water management notification or permit is necessary”, mentions the fact that the notification / permitting is granted for works, constructions and installations for water quality protection or which influence the quality of the waters of the groundwater injection type. The competence to issue water management notifications / permits for wastewater injections (mining, industrial waters) in very deep strata resides with the National Administration Romanian Waters.

Information on current monitoring requirements for treated effluent discharges and receiving water bodies (parameters, frequency) and associated sampling and testing costs.

Samples are taken from the control points on a period of 24 hours or at regular time intervals, proportionally with the evacuation debit – if deemed necessary, also at the entry into the treatment station – to follow compliance with the technical norms NTPA-011, as follows:

1. For sampling, national and international laboratory practices are applied - ISO or EN methods respectively – so that the degree of samples degradation between the moment of sampling and the moment of analysis is as low as possible.

2. The minimum number of samples, at regular time intervals, within a year, is set depending on the size of the treatment station, as follows:

a) for 2.000-9.999 population equivalent (PE) - 12 samples within the first year and 4 samples in the following years, if it can be demonstrated that within the first year the waters respect the prescriptions from the technical norms NTPA-011; if one of the 4 samples does not correspond to the technical norms, 12 samples will be taken in the following year:

b) for 10.000-49.999 PE - 12 samples;

c) for 50.000 PE or more - 24 samples.

It is considered that the treated wastewater respects the maximum admitted values for parameters that are relevant / of interest, if, for each relevant parameter, taken individually, the water samples show that this respects the set value, as follows:

a) for indicators/ parameters in table no. 1 of the technical norms NTPA-011 (biochemical oxygen consumption; chemical oxygen consumption; suspended solids), the maximum number of samples that might not correspond to the set values, expressed in concentrations or percentages in reductions, as laid down in table no. 3 from the technical norms NTPA-011;

b) it is considered inadequate samples those samples collected in normal exploitation conditions, in which concentrations found for indicators CBO(5) and CCO(Cr) in table no. 1 of the technical norms NTPA-011 divert with maximum 100% from the fixed values, and for the indicator Total solid suspensions, with maximum 150%;

c) for indicators in table no. 2 from the technical norms NTPA-011 (total phosphorus and total nitrates), the yearly sampling average for each indicator shall respect the set values.

Sampling and testing costs

As an example, a thorough list of testing costs is presented by the National Administration Romanian Waters, Water Management System Bucharest Ilfov[302]. Some of the testing costs are extracted below:

Indicator	Reference standard	Work field	Cost (EUR). VAT not included
CBO(5)	SR EN 1899-2:2002	0.5-6 ms/l	26 EUR
CBO(5)	SR EN 1899-1:2003	3-6000 ms/l	26 EUR
CCO-Cr	SR ISO 6060:1996	30-700 ms/l	26 EUR
CCO-Cr	ISO 15705:2002 (E)	10-150 ms/l	26 EUR
Total nitrogen	SR EN 12260:2004	l-20 ms./l total nitrogen	33 EUR

6.3 Agricultural irrigation: baseline

Agricultural sector profile

Data on agricultural land use

Table 6.7 presents the type of land use in Romania in 2013 and shows that arable land was the main land use.

Table 6.7 Repartition of agricultural land on type of uses in year 2013

Type of use	Surface	
	thousand ha	%
Total agricultural	14.611,9	100
Arable	9389.3	64.3
Grazing	3273.9	22.4
Meadows	1541.9	10.6
Vineyards	210,3	1.44
Orchards	196.5	1.30

Source: Romanian Statistical Yearbook, 2014

Data on crop production

The tables below present crop production and corresponding cultivated surface for the food to be cooked / processed those eaten raw and non-food crops. Main food crops cultivated in Romania are cereals (slowly ascending trend), potatoes (slowly descending trend), vegetables (ascending trend) and fruits (slowly ascending trend). Among non-food crops, hemps and linen have witnessed an ascending trend.

302 http://www.rowater.ro/daarges/Laboratoare/Documente%20Laborator%20Bucuresti/Tarife%20%20practicate%20de%20catre%20LCA%20Bucuresti.pdf

a) Food crops that will be cooked or processed

Culture	Cultivated surface (thousand ha)								Total production (thousand t)							
	2007	2008	2009	2010	2011	2012	2013	2014	2007	20 08	2009	2010	2011	2012	2013	2014
***Cereals Total, out of which*:**	5129,2	5210,7	5282,4	5040,6	5224,7	5440,3	5421,2	5442 ,1	7814,8	16826,4	14873	16712,9	20842,2	12824,1	20897,1	22065,7
Wheat + Rye	1987,1	2123,3	2164,3	2177,0	1959,4	2006,3	2114,7	2123 ,1	3065,0	7212,4	5235,5	5846,1	7163,0	5315,9	7320,2	7609,2
Barley +Two raw barley	363,8	394,0	517,5	515,8	419,5	424,2	495 ,7	516	531,4	1209,4	1182,1	1311,0	1329,7	986,4	1542,2	1712,4
Oats	208,7	200,4	202,7	181,4	185,3	194,5	182 ,2	179,7	251,6	382,0	295,8	304,5	375,9	339	373,8	381,6
Corn	2524,7	2441,5	2338,8	2098,4	2589,7	2730,2	2518,3	2512 ,8	3853,9	7849,1	7973,3	9042,0	11717,6	5953,4	11305,1	11988,6
Rice	8,4	9,9	13,3	12,4	12,7	11 ,3	11,5	11,3*	27,5	48,9	72,4	61,6	65,3	50,9	54,6	45,4*
***Oleaginous plants:* d .c**	1340,4	1239,4	1253,8	1409,7	1472,5	1261,1	1426,9	1496 ,5	1046,6	1942,3	1764	2377,7	2686,9	1667,7	2966,6	3460,6
Sunflower	835,9	813,9	766,1	790,8	995	1067,6	1074,6	1001	546,9	1170,0	1098,0	1262,9	1789,3	1398,2	2142,1	2189,3
Rapeseed -	364,9	365	419,9	537,3	392,7	105,3	276 ,6	406,7	361,5	673,0	569,6	943,0	739	157,5	666,1	1059,1
Soy	133,2	49,9	48,8	63,9	72,1	79 ,8	67,7	79,9	136,1	90,6	84,3	149,9	142,6	104,3	149,9	202,9
Beetle	28,7	20,4	21,3	22,0	18,8	27 ,3	28,1	31,3	748,8	706,7	816,8	837,9	660,5	719,8	1029,2	1398,6
Potatoes	268,1	255,3	255,2	241,3	242,6	223,5	203 ,4	198,5	3712,4	3649,0	4004,0	3283,9	4076,6	2465,2	3289,7	3519,3

Source: Romanian Statistical Yearbook, 2013 2014, tables 14.10, 14.11
National Institute of Statistics, Vegetal production for main cultures 2014
* Ministry of Agriculture and Rural Development

b) Food crops to be eaten raw - vegetables

Specification	Cultivated surface (thousand ha)								Total production (thousand t)							
	2007	2008	2009	2010	2011	2012	2013	2014	2007	2008	2009	2010	2011	2012	2013	2014
Field and greenhouse legumes, out of which:	253,4	268,6	267,1	262,7	263,4	258,9	259	239,5	3116,8	3819,9	3901,9	3863,6	4176,3	3535,3	3961,0	3807
Tomatoes	46	51,5	49,1	49,8	51 ,8	49,7	48,4	43,9	640,8	814,4	755,6	768,5	911,0	683,3	749,1	706,2
Dry onion	34,1	35	35,2	33,8	33 ,1	33,1	32,2	30	325	395,6	378,1	369,1	394,3	345,3	391,8	387
Dry garlic	11,5	13,8	13,1	12,8	12 ,1	11,4	10,6		49,9	72,3	63,2	67,2	66,6	59,4	62,2	
Cabbage	46,1	49	48,3	47,0	47 ,0	49,1	54,9	48	893,2	964,6	1001,9	981,2	1025,3	987,9	1156,4	1123
Pepper	18,6	20,2	20,0	21,0	20 ,0	19,9	19,5	18	184,9	238,7	245,7	243,5	253,5	207,1	227,7	229
Watermelon and	31	29,7	33,5	31,5	30 ,9	31,4	30,4	25,8	408	562,3	652,8	662,9	645,5	554,6	634,8	530,7

Source: Romanian Statistical Yearbook, 2013 2014, tables 14.10, 14.11
National Institute of Statistics, Vegetal production for main cultures 2014

c) Food crops to be eaten raw - grapes

	Surface (thousand ha)								Total production grapes (thousand t)							
	2007	2008	2009	2010	2011	2012	2013	2014	2007	2008	2009	2010	2011	2012	2013	2014
Grapes (vineyards)	187,6	187,9	184,4	177	176,6	178,7	178,4	176,7	873,2	996	990,2	740,1	879,5	746,4	991,6	783,7

Source: Romanian Statistical Yearbook, 2013 2014, table 14.13
National Institute of Statistics, Press release no. 75/ 31 March 2015 and National Institute of Statistics, Vegetal production for main cultures 2014

d) Food crops to be eaten raw - fruits

Specification	Total Production (thousand t)							
	2007	2008	2009	2010	2011	2012	2013	2014
Fruits Total, out of which:	1085,8	1179,2	1323	1419,6	1479,9	1128,5	1300,0	1301,4
Plums	372,6	475,3	533,7	624,9	573,6	421,4	512,5	495,3

Specification	Total Production (thousand t)							
	2007	2008	2009	2010	2011	2012	2013	2014
Apples	475,4	459	517,5	552,9	620,4	462,9	513,6	513,2
Pears	62,8	52,6	66,1	60,4	66,9	54,3	66,8	
Peaches and nectarines	17,0	16,4	17,1	11,2	22,5	17,4	19,1	
Cherries and sour cherries	65,2	67,7	67,9	70,3	81,8	70,5	80,5	82,8
Apricots	27,6	32,1	32,5	23,8	33,7	29,1	28,3	
Walnuts	25,5	32,3	38,3	34,3	35,1	30,6	31,8	
Strawberries	16,5	21,2	22	21,4	18,9	15,8	23,2	
Other fruits	23,2	22,6	27,9	20,4	27,0	23,9	24,2	

Source: Romanian Statistical Yearbook, 2013 2014, table 14.14
National Institute of Statistics, Vegetal production for main cultures 2014

e) Non-food crops - linen and hemp cultures

Specification	MU	2010	2011	2012	2013	2014
Surface	Ha	23,60	68,50	74,04	184,27	765,72
Total production	T	8	27,07	33,06	284,67	678,11

Source: 2010-2014 - Ministry of Agriculture and Rural Development operative data

f) Non-food crops - medicinal and aromatic plants

Specification	MU	2007	2008	2009	2010	2011	2012	2013	2014*	2015*
Surface	Th. Ha	7,4	7,3	10,1	15,9	11,8	5,8	4,7	3,2	3,2
Total production	Th. T	2,9	7,5	7,1	15,8	11,2	4,3	4,4	4,2	

Source: 2007-2013 - Romanian Statistical Yearbook
* Ministry of Agriculture and Rural Development, AGR2a data

g) Non-food crops - tobacco

Specification	MU	2007	2008	2009	2010	2011	2012	2013	2014*
Surface	Th. ha	1,1	1,2	0,9	1,5	1,7	1,3	0,9	0,7
Total production	Th. t	1,1	2,4	1,6	3,0	2,6	1,3	1,4	1,2

Source: 2007-2013 - Romanian Statistical Yearbook
* Ministry of Agriculture and Rural Development, AGR2B data

h) Non-food crops - hop

Specification	MU	2007	2008	2009	2010	2011	2012	2013	2014
Surface	Th. ha	440	501	456	215	232	241	239	245
Total production	Th. t	374	257	245	219	136	114	172	233

Source: 2007 - 2014 – Ministry of Agriculture and Rural Development, AGR2B operative data

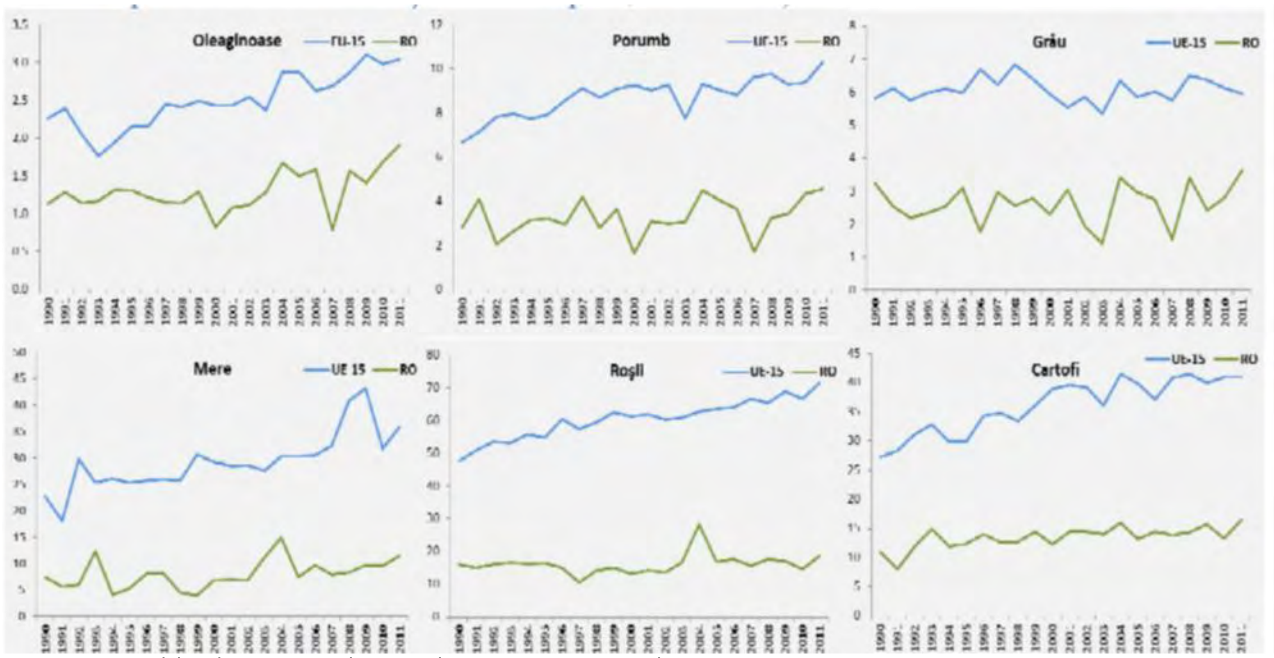
Information on average crop productivity

Average crop productivity for main crops is just a third or a half of the ones registered in EU-15: for common wheat, 2,6 tones/ha, compared to 6,1 tones/ha, for corn, 3,2 tones/ha, compared to 8,7 tones/ha and for oleaginous seeds 1,3 tones/ha, compared to 2,4 tones/ha (average productivity for years 1990-2012).

Large gaps in productivity are registered also in case of rye (RO is situated at 55% of EU average) and barley (64% of EU average) [303]. The situation reveals the lack of mature technologies and biologic material adapted to the pedo-climatic conditions of Romania.

Productivity of potato cultures is also low, the 2001-2011 averages being just 54% of the EU 27average. Figure 6.1 shows detailed productivity for the years 1990 – 2011 for the following crops: oleaginous plants, corn, wheat, apples, tomatoes, potatoes. The figure also compares the Romanian productivity of the respective crops to the EU average.

Figure 6.1 Crop productivity in Romania and EU for selected crops 1990-2011



Source: Eurostat *(oleaginous, corn, wheat, apples, tomatoes, potatoes)*

The average crop value by crop type, average of Romanian representative markets, as of 20 April 2016 are presented below:

Crop	Average Price (EUR)
Bread-making wheat	141,15
Fodder	145,95
Feed barley	118,27
Corn	132,08

Source: Ministry of Agriculture and Rural Development, Price of cereals on representative markets of Romania, 2016

Agricultural irrigation

Agricultural irrigation in Romania

Romania has a total irrigated area of 2.991.943 ha, out of which:

- Spray irrigation 2.665.594 ha;
- Bed irrigation 276.624 ha; and
- Flooding 49.725 ha.

The water used for irrigations are mostly from surface water[304]:

- Danube (85%) 2.543.150 ha; and

[303] Eurostat
[304] National Agency for Land Reclaim ANIF

- inland rivers and storage reservoirs (15%) 448.793 ha

Irrigated surface in Romania decreased from 2 million ha at the end of the 1980s /beginning of the 1990s, to approximatively 0,8 million ha (considered irrigable with functional infrastructure), because installations that are not economically viable have been closed. Actually, irrigated land counts for less than 300.000 ha (less than 1% of the total arable land) in the last 5 years (2011 – 2015). Necessary water resources were reduced from approximatively 8 MCM (million m^3) to 1 MCM a year. Although the general situation seems to be good due to over-capacity, there are areas with water deficits in many basins where summer drought represents a serious concern.

The surface effectively irrigated remains small in comparison with the real need (only 1.2% of UAA in 2012). According to the national Strategy of investments in the irrigation sector, priority will be granted to investments in modernisation and less in the creation of new infrastructure.1.502.251 ha are identified for rehabilitation and improvement of water consumption for the existent infrastructure, on short and medium term. Of that surface, 823.130 ha have been declared by ANIF as viable from the economic point of view, through the Project for Rehabilitation and Reform of the Irrigation Sector (PRRSI). Out of the 823.130 ha, 619.916 ha represent lands covered with viable infrastructure and recently used, for which modernisation investments are necessary. Irrigations systems in Romania are defective for a great part of lands. Absence or the great extent of degradation in the irrigation infrastructure resulted in approx. 48% of the arable land (7,1 mil ha, in 2006) to be affected by drought. The volume of water used for irrigation increased with 52,65%, from 212.979 thousand m^3 in 2010, to 325.127 thousand m^3 in 2012, but agriculture in Romania remains dependent to climatic factors. The negative effects of drought are reflected mainly in the low productivity registered for main crops (35-60% of potential).

Information on irrigation costs

An extensive list with prices set up by ANIF for irrigated areas in the country is available[305]. Below there are examples of irrigation costs in different irrigated areas located in Romania.

Administration unit: Arad

Facility: Semlac Pereg

Grade	Plot name	Yearly tariff at the delivery point (EUR / ha)	Delivery tariff at the delivery point (EUR / 1000 m^3)
1	Peregul Mare	1,37	26,41
1	Semlac	1,37	19,73
Facility: Fantanele Sagu			
1	Fantanele Sagu	4,39	16,13

Note: The tariffs above do not include VAT.

Structure of irrigated crops at national level

Following the freeze of subventions for irrigations in 2010, the structure of irrigated crops is headed towards the efficiency of the systems in performant countries, but the irrigated area decreased significantly afterwards. Rice holds an important place in the structure of irrigated crops (17%), soy reaches 13% and legumes 13%.

Table 6.8 Structure of irrigated crops at national level (%)

Type of crop	2009	2010
Cereals	26	22
Corn consumption	27	27
Sunflower	14	3
Rape	11	1

305 http://www.anif.ro/tarife/20150609-Tarife%20iunie%202015.pdf

Type of crop	2009	2010
Seed lots	11	Na
Rice	4	17
Soy	2	13
Legumes/Fruits	3	13
Fodder	1	2
Others	1	4
Irrigated surface (ha)	293.000	73.000

Source: 2009 PRRSI, representative study „Payment capacity of the irrigation costs by the Organisations of Irrigation Water Users,"; 2010 – ANIF.

The main irrigated lands in 2009 were:

- Great Braila Island (37.456 ha);
- Covurlui Plain (Galati, 28.382 ha);
- Ialomita Calmatui Terrace (Ialomita, Braila – 28.315 ha);
- Braila Terrace (22.725 ha); and
- Viziru Terrace (13.353 ha).

Regarding the volume pumped in 2009, the two facilities where most pumping occurred were the rice plantations Calmatui-Gropeni-Chiscani (73.522.000 cm), and Luciu-Giurgeni (53.726.000 cm), followed by other farms: Brailei Terrace (38.243.000 cm), Ialomita-Calmatui Terrace (37.810.000 cm), Covurlui Plain (37.404.000 cm).

There is no publicly available information on the annual tonnage and value of crops produced under irrigation.

Current potential for treated wastewater reuse in agricultural irrigation

Although the legislation does not forbid the use of treated wastewater in irrigation, there are not enough specific regulations and standards that would make the water reuse option a real possibility. Only quality standard for irrigation from surface water resources are available (*STAS 9450-88 - Waters for crop irrigations*). Additionally, the low number of users that are connected to the irrigation system and the relatively low water volume that is used for irrigations at national level does not currently act as an incentive to invest in further technologies.

Contacted to express their point of view on these matters, the representatives of the Ministry of Environment, Waters and Forests highlighted the fact that there is some concern in regard to the use of treated wastewater in irrigations, due to the safety / human health issues it might provoke. The representatives believe that the priorities of the sector lie with the reduction of specific water quantities used in industry and agriculture by reducing the losses, the application of modern technology irrigations (spray and drip irrigation, sub-irrigation) and the reuse of wastewater in technological processes that do no necessitate a certain water quality.

In the long run, the interest in treated water reuse for irrigation might increase, as forecasts predict a significant increase of the number of users connected to the irrigation system, while research has begun to study the conditions under which treated wastewater could be used in agriculture at experimental level.

Currently, there are no specific regulations and standards that would make wastewater reuse applicable on the large scale, although the legislation does not forbid the use of treated wastewater in irrigation. There is currently some experimental research being conducted: The Electro Technical Research Institute Bucharest, in partnership with the Electro Technical Research Institute Bistrita and the Polytechnical University Bucharest carried a project which aims to develop an autonomous integrated treatment system for domestic wastewater that would reuse water and sludge.

With that being noted, it is unlikely that legislation and regular practice on treated water reuse would develop at a quick pace, in the absence of an EU-level instrument. As explained also in the paragraph above, currently there are too few pressures that would make reused water for irrigations an absolute necessity, so that irrigators and policy makers start taking a closer look at this option. Pressure is likely to mount in the following years, given the investments done to revitalise the irrigation systems, the effects of climate change leading to increased droughts in some regions of Romania and the scientific / business areas being more interested in this subject as well. Any change in the policy making will occur at a slow pace, however.

6.4 Agricultural irrigation: proposal

Non-binding standards for water reuse

Promotion of non-binding standards for water reuse would come as an assisting instrument which would develop the treated water reuse framework in Romania. While there is no specific legislation that refers to reuse of treated wastewater in agricultural irrigation, there is some general legislation referring to water reuse. The amended technical norms from 28 February 2002 regarding collection, treatment and evacuation of urban wastewater, NTPA-011, which is annex to the Government Decision no. 188/20.03.2002 approving norms for discharging into aquatic environment of used waters, subsequently amended and completed, states in article 6 state treated wastewater will be reused anytime this is possible, with the permit of the competent authorities, depending on its origin and the field of use. Reuse of these waters must be done with the aim of reducing the negative effects on environment to a minimum.

Adoption of non-binding standards for treated water reuse in irrigations would be beneficial, as there are no such specific standards and regulations in Romania, which would make large scale use of treated wastewater otherwise impossible. One must take into consideration however the fact that the Ministry of Environment, Waters and Forests does not see the adoption of such standards as an absolute necessity, a fact which might delay their adoption.

Legally binding standards for water reuse

While the current legal framework in Romania allows the reuse of treated wastewater, it does not have specific standards and regulations referring to irrigation that would allow large scale implementation of this concept.

Since the Ministry of Environment, Waters and Forests currently does not see the adoption of such standards an absolute necessity, this might delay their adoption.

From a practical point of view, adoption of binding standards in the Romanian context would require the combined work of different authorities at governmental level (agriculture, environment, health…), standardisation organisations, with input from associations of farmers that are connected / intend to connect to the irrigation system, water operators, other public agencies. The standards would then be part of the legal Romanian system (e.g. adoption by Government Decision or Ministry Order). By adoption of the standards, the monitoring requirements for treated effluent discharges and receiving water bodies will need to be upgraded for the wastewater to be reused for irrigation, since the current legislation (Technical norms NTPA 011 / 2002) request less monitoring parameters than the parameters laid down in the JRC proposal.

6.5 Agricultural irrigation: impact assessment

Non-binding standards for water reuse

The table below summarises the impacts identified for a non-binding instrument on water reuse for agriculture irrigation.

Economic impacts	
Functioning of the internal market and competition	In theory, non-binding standards might create some disturbances in the functioning of the competition, both at the level of water suppliers and of the farmers, since some of them will take a pledge to respect the standards and make investments in this direction, while others will not. Currently this is risk is low for Romania, since there is only one major irrigation supplier (National Agency for Land Reclaim), which will most likely harmonise its practices across regions.
Operating costs and conduct of business/Small and Medium Enterprises	Depending on the price of the reused wastewater, application of this instrument might have a limited applicability, since most Romanian farmers are unable to afford irrigation at the current prices, let alone increased prices for treated water reuse. This picture can change in the future, with forecasts predicting a rapid development of agriculture in Romania and climate change bringing more drought in some regions, making irrigation a vital necessity. Water suppliers that choose to apply the non-binding standards will also be affected by higher initial investments and increased sampling costs and possibly a lack of demand of the reused wastewater from the farmers.
Administrative burdens on businesses	While the likelihood of additional administrative burdens on businesses is low, due to lack of policy monitoring and evaluation, there might be some situations where administrative burdens will increase, on a case by case basis (e.g. for some types of crops, water suppliers from a heavily polluted region etc.)
Public authorities	Public authorities will have the responsibility to adapt and adopt the non-binding standards to the Romanian context. Since the Ministry of Environment, Waters and Forests currently does not see the adoption of such standards an absolute necessity, this might delay their adoption. This task might create some more technical problems with adoption, since knowledge and experience on treated water reuse is missing. Otherwise, since there is no monitoring and no evaluation involved, few other responsibilities are estimated.
Innovation and research	The non-binding standards would come to the assistance of the research community which showed some interest in this technical possibility (http://www.icpe.ro/ro/p/siera_2016_ro)
Consumers and households	Introduction of non-binding standards in water reuse will have an impact in the price of the agricultural and food products. Issues related to the quality of irrigation water, hence the quality of agricultural products and food products might also be of concern for consumers, especially since currently treated water is not reused in irrigations. Consumers might encounter this new practice with suspicion. Depending on the communication requirements of the non-binding standards, they might affect consumer information and protection.

Social impacts	
Employment and labour markets	The introduction of water reuse standards might create new jobs in water treatment and innovation and research.
Governance, participation, good administration, access to justice, media and ethics	Water quality standards are protecting consumers, who are supposed to be better informed about the quality of the water they use and the agricultural/food products they buy.
Public health and safety	The option positively affects the health and safety of individuals/populations, including life expectancy, mortality and morbidity. The option also decreases the likelihood of health risks due to substances harmful to the natural environment. Since the standards are non-binding however and there will be no monitoring and evaluation with this option, it will be difficult to calculate an actual impact on public health and safety.

Environmental impacts	
Water quality and resources	The option increases the quality of fresh water, due to the extra treatment the waste water is being subjected to, and does not affect drinking water resources. It will be impossible however for the environmental impact to be measured exactly, since the option does not provide monitoring and evaluation.
Renewable or non-renewable resources	The option does not significantly affect renewable or non-renewable resources, since the amount of water used for irrigation does not increase by adopting this option.
The environmental consequences of firms and consumers	If implemented correctly, this option will lead to more sustainable production and consumption. From a price point of view, however,

	products irrigated with retreated wastewater might become more expensive, due to increased investments in additional cleaning of the water.

Legally binding standards for water reuse

The table below summarise the impacts identified for a legally binding instrument for agriculture irrigation.

Economic impacts	
Functioning of the internal market and competition	Adoption of minimum standards mandatory across EU will allow for an informed and safe consumer choice, with no disturbance of the internal market.
Operating costs and conduct of business/Small and Medium Enterprises	Water suppliers and farmers that that choose to operate with treated wastewater will be affected by higher initial investments in additional water treatment, which might lead to a lack of demand for reused wastewater from the farmers. This issue is particularly sensitive, because due to lack of funds, most Romanian farmers do not use irrigation at all currently and further increases in price would push them even more from connecting to the irrigation system. The same issue of costs might act as a barrier for the water operators that are treating the wastewater. Currently there is no water operator to treat wastewater for irrigations. Given also this lack of experience with reusing treated wastewater, water operators might be reluctant to invest in technologies and accept additional sampling / testing costs to further treat the wastewater for irrigation, if they are insecure about farmers being interested in buying their "product", if the price is higher than that of the regular water they supply. This picture might change however in the future, when more farmers will access the irrigation system, due to forecasted expansion of the agriculture sector and increased drought brought by climate change.
Administrative burdens on businesses	Depending on the requirements of the standard (the type of data required, reporting frequency, the complexity of submission process), it is likely that both farmers and water suppliers will experience increased administrative burdens for the monitoring and evaluation purposes. This might trigger additional costs (e.g. new staff, new expertise required).
Public authorities	Public authorities will have the responsibility to adapt and adopt the non-binding standards to the Romanian context. Since the Ministry of Environment, Waters and Forests currently does not see the adoption of such standards an absolute necessity, this might delay their adoption. The task might also create some technical problems with adoption since knowledge and experience on treated water reuse is missing. Monitoring and evaluation will also create additional burdens and costs for public authorities. It is possible that new departments will be created and / or new staff will be hired at the level of some authorities (e.g. National Administration "Romanian Waters", County Departments of Agriculture).
Innovation and research	Application of binding standards would be a boost for the research community which already showed some interest in this technical possibility (http://www.icpe.ro/ro/p/siera_2016_ro)
Consumers and households	Introduction of standards in water reuse will have an impact on the price of the agricultural and food products, since meeting those standards requires additional investments from the water suppliers. Issues related to the quality of irrigation water, hence the quality of agricultural products and food products might also be of concern for consumers, especially since currently treated water is not reused in irrigations. Consumers might encounter this new practice with suspicion. Depending on the communication requirements of the standards, they might affect consumer information and protection.

Social impacts	
Employment and labour markets	The introduction of water reuse standards might create new jobs in water treatment and innovation and research.
Governance, participation, good administration, access to justice, media and ethics	Water quality standards are protecting consumers, who are supposed to be better informed about the quality of the water they use and the agricultural/food products they buy.
Public health and safety	The option positively affects the health and safety of individuals/populations, including life expectancy, mortality and morbidity. The option also decreases the likelihood of health risks due to substances harmful to the natural environment. Since the option also includes monitoring and evaluation, it will be easy to assess and monitor the impact of the standards on the public health and safety. Romania has very little experience with wastewater reuse in irrigations, which make monitoring and evaluation of delivered wastewater an extra guarantee that all partners involved will take this practice seriously, limiting the likelihood of any accidents or mishandling of the treated wastewater.

Environmental impacts	
Water quality and resources	The option increases the quality of fresh water, due to the extra treatment the waste water is being subjected to, and does not affect drinking water resources. Since the option also includes monitoring and evaluation, it will be easy to assess and monitor the impact of the standards on water quality and resources.
Renewable or non-renewable resources	The option does not significantly affect renewable or non-renewable resources, since the amount of water used for irrigation does not increase by adopting this option.
The environmental consequences of firms and consumers	If implemented correctly, this option will lead to more sustainable production and consumption. From a price point of view, however, products irrigated with retreated wastewater might become more expensive, due to more expensive technology used to clean the water.

6.6 Agricultural irrigation: Comparison of the alternative policy options

Adopting the option of the non-binding standards bring a series of advantages and disadvantages for Romania. Among the positive impacts that this option would bring, we can name the following:

- Non-binding standards do not create much pressure on the status-quo initial situation. This approach might be suitable in countries like Romania, which do not have practical experience with reusing treated water. The adopted standards would give interested water operators and farmers a place of reference. Adoption of non-binding standards would come at an appropriate moment, since a vigorous growth in the agriculture sector is forecasted, which would add pressure to the water demand for irrigations, especially in the context of extended droughts caused by climate change[306];
- Adoption of non-binding standards would slowly prepare the Romanian interested stakeholders in dealing with reused wastewater and in understanding / accepting new later steps of the policy (binding standards, targets for water reuse);
- This option will create less administrative burdens and costs both for water operators, farmers and the public authorities, since there is no monitoring and evaluation involved. This context might again be suitable for countries like Romania, which are just starting to get used to this concept. Since the majority of Romanian farmers cannot afford irrigation due to high costs with water, it is important not to place additional burdens and costs on them at this moment; and
- Setting standards would boost and support research in this area, which already exists but is limited to a handful of experimental projects.

[306] For additional information see the prognosis of the National Prognosis Commission 2016 – 2019 http://www.cnp.ro/user/repository/prognoze/prognoza_2016%20-%202019_varianta_de_primavara.pdf , as well as other related articles: http://www.wall-street.ro/articol/Economie/153663/erste-prognoza-crestere-economica.html ; http://www.agro-tv.ro/comisia-europeana-prognozeaza-o-crestere-semnificativa-a-productiei-agricole-din-romania/

Among the negative impacts this option might bring, the following can be noted:

- Adoption of non-binding standards might create some disturbances in the functioning of the competition, both at the level of water suppliers and of the farmers, since some of them will take a pledge to respect the standards and make investments in this direction, while others will not. Currently this is risk is low for Romania, since there is only one major irrigation supplier (National Agency for Land Reclaim), which will most likely harmonise its practices across regions; and
- Since this option does not include monitoring and evaluation, it does not allow to draw lessons from the implementation of the standards, giving less objective information about the next steps which are needed. It also does not allow to calculate impacts on environment, safety, public health etc.

As a conclusion, however, despite the disadvantages that this option brings, it seems to be the most suitable one for the immediate future, the main motivation being that an optional new policy that brings too high costs on water operators and farmers has all the chances to not be implemented at all.

Adopting the option of the binding standards also bring its advantages and disadvantages for Romania. Among the positive impacts that this option would bring, we can name the following:

- There are clear rules for all the users that are interested in reusing treated wastewater, which brings transparency and eliminates any disturbances in the competition;
- It is a complete option, meaning that no policy can be effective without following the whole policy cycle, which includes monitoring and evaluation. Although costly, monitoring and evaluation will bring much needed data based on which policies can be bettered and proper action can be taken. This includes a proper calculation of impact assessment on health, safety, environment etc.; and
- While non-binding standards would already boost innovation and research in this area, setting binding standards would amplify this phenomenon even more.

The main disadvantages of this option are the costs of implementation, which would translate in financial and administrative burdens for farmers, water operators and public authorities. These burdens have a high potential to create aversion to this policy given the low financial capability of farmers in Romania. The use of irrigation systems is already a rarity in Romania (only 100.000 ha irrigated in 2015 in comparison with 2.000.000 ha in 1990) and increasing its costs would only make farmers less interested in using irrigation.

On a medium term outlook, this option seems to be the most suitable one, especially taking into consideration that more farmers will access the irrigation system in the future, due to forecasted expansion of the agriculture sector and increased drought brought by climate change.

For both options however, the response of the representatives of the Ministry of Environment, Waters and Forests must be noted. The officials expressed some concern in regard to the use of treated wastewater in irrigations, due to the safety / human health issues it might provoke. The representatives believe that the priorities of the sector lie with the reduction of specific water quantities used in industry and agriculture by reducing the losses, the application of modern technology irrigations (spray and drip irrigation, sub-irrigation) and the reuse of wastewater in technological processes that do no necessitate a certain water quality. Under such conditions, the adoption of any of the options can be delayed.

6.7 Aquifer recharge: baseline

Groundwater resources

The potential of groundwater is estimated at 10 MCM/year. In Romania, groundwater is generally used for population water supply, but also for industrial, farming and other purposes. In 2013, 46 significant exploitation of groundwater, i.e. catchments with flows higher or equal with 1500 thousand m^3/year were identified at national level.

Groundwater is not overexploited in Romania.

Continuing the trend of the last years, data in 2014 showed that surface water abstraction accounted for around 10 times the volume of water abstracted from groundwater resources.

In 2014, according to second RBMP (2015), the situation of the 143 assessed groundwater bodies is the following:

- 128 groundwater bodies are of good chemical state (89,51 %); and
- 15 groundwater bodies are of poor chemical state (10.49 %).

By analysing the data obtained following the monitoring of the drilling situated on the groundwater bodies, most spill overs are recorded for the following indicators: nitrates, ammonium, chlorides and sulphates.

Aquifer recharge

Existing requirements restricting/ regulating aquifer recharge

The Waters Law prohibits injections of wastewater into groundwater. The same law states however that the right to use surface and groundwater is established through the water management permit. This right includes, among other things, the right to discharge wastewaters.

Order no. 662/2006 which approves the “Procedure and competences to issues water management notifications and permits”, art. 8, Annex 1a - “The list of works and categories of activities placed on waters or which are connected with waters, for which a water management notification or permit is necessary”, mentions the fact that the notification / permitting is granted for works, constructions and installations for water quality protection or which influence the quality of the waters of the groundwater injection type. The competence to issue water management notifications / permits for wastewater injections (mining, industrial waters) in very deep strata resides with the National Administration Romanian Waters.

Aquifer natural recharge in Romania is done through surface and rainwater infiltration. Regarding the take-off / recharge balance, which concurs to the evaluation of the aquifer from a quantitative point of view, there are no special problems, the take offs being inferior to the natural rate of recharge[307].

There have been some experimental projects done which tested the practice of artificial recharge of aquifers:

- Aquifer recharge in the Calafat – Ghidiciu area, with water from the Danube[308];
- Theoretical calculations on aquifer recharge for the Banat Plain and Oltenia Plain, as part of the EU-funded project Climate Change and Impacts on Water Supply - CC WaterS[309]; and
- Research was conducted into the feasibility of underground storage for water during periods of severe drought or heavy rainfall as part of the Dutch funded project MARS - Management of Aquifer Recharge and Storage[310].

There is no aquifer recharge using treated wastewater in Romania, since this is prohibited by law.

Potential for treated wastewater reuse in aquifer recharge

The current potential for treated wastewater reuse in aquifer recharge is very low, given that it is prohibited by law. Officials at the Ministry of Environment, Waters and Forests pointed out that use of treated wastewater for aquifer recharge is not currently of interest for Romania. There is an interest however in the indirect discharge of wastewater in groundwater, in locations where there are no surface waters within reasonable distance (this is the case of many localities in Dobrogea). Interest exists also in the development

[307] Report on the State of Environment 2015
[308] For more information, see http://www.danube-water.ro/danubeinfo/assets/library/2%201%20Modele%20ape%20subterane.pdf
[309] For more information, see http://www.ccwaters.eu/index.php?option=com_content&view=frontpage&Itemid=1; http://www.inhga.ro/proiectul-cc-waters
[310] For more information, see http://www.dutchwatersector.com/solutions/projects/239-mars-project.html

of standards that would detail the quality of wastewater that would be discharged in biological ponds which allow the infiltration of these waters into groundwater.

Additionally, groundwater is not used very frequently and the aquifers from which water is abstracted replenish themselves naturally, with a few exceptions. In other words, there is little need for aquifer recharge in general.

In the future, the picture might change due to increased droughts brought by climate change and economic growth which will generate more water consumption.

Water shortage in Romania is likely to be mounting problem, as water consumption will continue to grow due to economy growing up, while droughts will appear more and more frequently due to climate change. In these conditions, water specialists might start to look more and more frequently to the option of reusing treated wastewater for aquifer recharge. It is unlikely that aquifer recharge with treated wastewater would be a natural choice on a short and medium framework, given the legal prohibition of this method, but also the lack of experience and the costs associated with this method.

6.8 Aquifer recharge: proposal

Non-binding standards for water reuse

Since the Waters Law prohibits the injection of wastewaters into groundwater, the non-binding standards cannot be transposed without changing the legal provisions first. If the Waters Law will be changed, transposition of non-binding standards in the Romanian context would require the combined work of different authorities at governmental level (environment, water management, health…), standardisation organisations, other public agencies.

Legally binding standards for water reuse

Since the Waters Law prohibits the injection of wastewaters into groundwater, the binding standards cannot be transposed without changing the legal provisions first. If the Waters Law will be changed, transposition of binding standards in the Romanian context would require the combined work of different authorities at governmental level (environment, water management, health…), standardisation organisations, other public agencies. By adoption of the standards, the monitoring requirements for treated effluent discharges and receiving water bodies will need to be upgraded for the wastewater to be reused for irrigation, since the current legislation (Technical norms NTPA 011 / 2002) request less monitoring parameters than the parameters laid down in the JRC proposal (i.e. those of the Drinking Water Directive).

6.9 Aquifer recharge: impact assessment

Non-binding standards for water reuse

Economic impacts	
Operating costs and conduct of business/Small and Medium Enterprises	Application of non-binding standards will increase the costs of the water supplier, since water will need to be treated additionally to ensure the required quality. This involves further investments, costs with samplings, testing etc. It will also entail stricter regulation of the conduct of the particular water supplier.
Administrative burdens on businesses	The administrative burdens will likely increase, since the national company which will overtake the water resource management (Romanian Waters) and recharge the aquifer will demand regular information, testing etc. from the water supplier which delivers the treated wastewater. This will act as a burden on the water suppliers.
Public authorities	Public authorities will have the responsibility to adapt and adopt the non-binding standards to the Romanian context. Adoption of standards cannot be done without lifting the prohibition to discharge wastewater into groundwater. The lack of support from the Ministry of Environment in the adoption of these standards will also act as a barrier. The task might create some technical problems as well, since knowledge and experience on treated water reuse is missing. Otherwise, since there is no monitoring and no evaluation involved, few other responsibilities are estimated.
Innovation and research	The non-binding standards would come to the assistance of the research community, although there is no evidence that this subject had been so far approached by Romanian research institutes.
Consumers and households	Consumers will likely need to pay increased prices for water. Issues related to the quality of water might also be of concern for consumers, especially

Economic impacts	
	since currently aquifers are not recharged with treated wastewater. Consumers might encounter this new practice with suspicion. Depending on the communication requirements of the non-binding standards, they might affect consumer information and protection.

Social impacts	
Employment and labour markets	Promotion of water reuse in Europe through the introduction of water reuse standards might create new jobs in water treatment and innovation and research.
Governance, participation, good administration, access to justice, media and ethics	Water quality standards are protecting consumers, who are supposed to are better informed about the quality of the water they use.
Public health and safety	The option positively affects the health and safety of individuals/populations, including life expectancy, mortality and morbidity. The option also decreases the likelihood of health risks due to substances harmful to the natural environment. Since the standards are non-binding however and there will be no monitoring and evaluation with this option, it will be difficult to calculate an actual impact on public health and safety.

Environmental impacts	
Water quality and resources	The option does not significantly decrease or increase the quality or quantity of freshwater and groundwater, unless the requirements of the standard are lower / higher that the water that naturally recharges aquifers at present times (surface and rainwater).
Renewable or non-renewable resources	The option does not significantly affect renewable or non-renewable resources, unless the requirements of the standard are lower / higher than those of the waters that naturally recharge aquifers at present times.
The environmental consequences of firms and consumers	The option can lead to more sustainable groundwater use.

Legally binding standards for water reuse

Economic impacts	
Operating costs and conduct of business/Small and Medium Enterprises	Application of legally binding standards will increase the costs of the water supplier, since water will need to be treated additionally to ensure the required quality. This involves further investments, costs with samplings, testing etc. It will also entail stricter regulation of the conduct of the particular water supplier.
Administrative burdens on businesses	The administrative burdens will likely increase, since the national company which will overtake the treated wastewater (Romanian Waters) and recharge the aquifer will demand regular information, testing etc. from the water supplier which delivers the treated wastewater. This will act as a burden on the water suppliers.
Public authorities	Public authorities will have the responsibility to adapt and adopt the binding standards to the Romanian context. Adoption of standards cannot be done without lifting the prohibition to discharge wastewater into groundwater. The lack of support from the Ministry of Environment in the adoption of these standards will also act as a barrier. The task might create some technical problems as well, since knowledge and experience on treated water reuse is missing. Monitoring and evaluation will also create additional burdens and costs for public authorities. It is possible that new departments will be created and / or new staff will be hired at the level of some authorities (e.g. Romanian Waters, water operators, etc.).
Innovation and research	The binding standards would come to the assistance of the research community, although there is no evidence that this subject had been so far approached by Romanian research institutes.
Consumers and households	Consumers will likely need to pay increased prices for water. Issues related to the quality of water might also be of concern for consumers, especially since currently aquifers are not recharged with treated wastewater. Consumers might encounter this new practice with suspicion. Depending on the communication requirements of the binding standards, they might affect consumer information and protection.

Social impacts	
Employment and labour markets	Promotion of water reuse in Europe through the introduction of water reuse standards might create new jobs in water treatment and innovation and research.
Governance, participation, good administration, access to justice, media and ethics	Water quality standards are protecting consumers, who are supposed to are better informed about the quality of the water they use and the agricultural/food products they buy.
Public health and safety	The option positively affects the health and safety of individuals/populations, including life expectancy, mortality and morbidity. The option also decreases the likelihood of health risks due to substances harmful to the natural environment. Since the option also includes monitoring and evaluation, it will be easy to assess and monitor the impact of the standards on the public health and safety. Romania has very little experience with wastewater reuse in aquifer recharge, the binding framework which make monitoring and evaluation of delivered wastewater an extra

Social impacts	
	guarantee that all partners involved will take this practice seriously, limiting the likelihood of any accidents or mishandling of the treated wastewater.

Environmental impacts	
Water quality and resources	The option does not significantly decrease or increase the quality or quantity of freshwater and groundwater, unless the requirements of the standard are lower / higher that the water that naturally recharges aquifers at present times (surface and rainwater).
Renewable or non-renewable resources	The option does not significantly affect renewable or non-renewable resources, unless the requirements of the standard are lower / higher than those of the waters that naturally recharge aquifers at present times.
The environmental consequences of firms and consumers	The option can lead to more sustainable groundwater use.

6.10 Aquifer recharge: Comparison of the alternative policy options

Before doing a comparison of the alternative policy options, it must be noted that for both options, there is a serious barrier arising from the legal framework in Romania which prohibits discharge of wastewater into groundwater. This is significant impediment which lowers the significance of the comparison, as long as it is still in place.

Another impeding factor for both options is the fact that most aquifers in Romania charge naturally with surface and rainwater, so they do not need to be charged artificially.

Taking into consideration these two factors, it is safe to affirm that both policy options (non-binding and binding standards) have a low chance to be implemented in the short and medium term in Romania. Regarding the long term outlook, however, the situation might present itself differently, estimating that in the meantime the legal framework will be changed and aquifer recharge will become more of a necessity due to more intensive exploitation of groundwater.

Under the current conditions, it is difficult to estimate which of the two options is better suited for the moment when the conditions are filled so that implementation of any of the standards becomes a real possibility. Both options come with their advantages and disadvantages and a better comparison is suitable to be done at a later point in time.

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KH-01-16-909-EN-N

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doi:10.2779/974903