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IMPACT ASSESSMENT

Accompanying the document

Proposal for a Regulation of the European Parliament and of the Council on minimum requirements for water reuse

{COM(2018) 337 final} - {SEC(2018) 249 final} - {SWD(2018) 250 final}

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INTRODUCTION

Water is already a limited resource, with one third of Europe experiencing water stress. The growing needs of populations and climate change will make the availability of water in sufficient quantity and quality even more of a challenge in Europe in the future. Water scarcity is no longer confined to a few corners of Europe, and is already a concern across the EU with significant environmental and economic consequences; projections suggest that the situation will become much more pronounced in the coming years.

To respond to this problem, Europe's water resources should be managed more efficiently. In addition to water savings, securing the supply of good quality water can help address water scarcity in the context of an integrated approach to water management. Reusing water after treatment constitutes an effective and sustainable alternative water supply, and so can be a useful tool for managing water resources. For example, this can involve a treatment plant receiving waste water from domestic uses and then treating it separately and providing it by pipe to farmers, instead of returning it directly to a river. It extends its life cycle, thereby helping to preserve water resources as part of an integrated approach to water management and in full compliance with the circular economy objectives. Today, whilst water reuse in the EU could obviously never by itself solve water scarcity problems, it falls far below its full potential.

The Commission has been considering the issue of water reuse for a number of years and has documented its findings to date in several steps. In the 2012 Communication "A Blueprint to Safeguard Europe's Water Resources" (COM(2012) 673) water reuse for irrigation or industrial purposes was found to have a lower environmental impact and potentially lower costs than other alternative water supplies, whereas it is only used to a limited extent in the EU. A Fitness check of EU Freshwater policy (SWD(2012) 393) published in November 2012, as a building block of the Blueprint, assessed the performance of the measures taken, both in environment and in other policy areas, in achieving the objectives already agreed in the context of water policy. It also identified the major gaps to be closed in order to deliver environmental objectives more efficiently. In relation to waste water reuse, the Fitness Check concluded that "alternative water supply options with low environmental impact need to be further relied upon" in order to address water scarcity. A particular issue emphasised by stakeholders in the public consultation of the Fitness Check was the lack of EU common quality requirements for reuse of waste water in irrigation. Several policy options to promote water reuse were considered in the impact assessment of the Blueprint (SWD(2012) 382)[1] A number of actions to promote water reuse were included in the Communication "Closing the loop – An EU action plan for the circular economy" (COM(2015) 614), and in particular a legislative proposal on minimum requirements for reused water for irrigation and groundwater recharge. This proposal has also been included in the European Commission's 2017 Work Programme as it contributes to the political priorities set by the Commission to promote a more circular economy. In addition, it may complement the planned future modernisation of the Common Agricultural Policy.[2] Finally, the initiative could contribute to the EU's implementation of the Sustainable Development Goals (SDGs) and in particular

[1] It concluded: "*Regarding water re-use there is a need to ensure the effective operation of the Internal Market to support investment and use of re-used water. The assessment, including stakeholder consultation, found that this can only be achieved through the development of new regulatory standards at EU level. Therefore, the preferred option is for the Commission to pursue appropriate health/environment protection standards for re-use of water and, subsequently, to propose a new Regulation containing these subject to a specific impact assessment.*"

[2] To note in this context that reference to water reuse is made in a Commission Staff Working Document on Agriculture and Sustainable Water Management in the EU (SWD(2017) 153final) as one of a number of measures that has the potential to reduce negative impacts associated with over-abstraction.

SDG 6 on Clean Water and Sanitation, which sets a target of substantially increasing recycling and safe reuse globally by 2030.

The intention to address water reuse with a new legislative proposal was noted with interest by the Council, in its conclusions on the Commission's Communications on the Blueprint and on Circular Economy and in its conclusions on Sustainable Water Management (11902/16). Furthermore, the European Parliament, in its Resolution on the follow-up to the European Citizens' Initiative Right2Water in September 2015, encouraged the Commission to draw up a legislative framework on water reuse, as well as the Committee of the Regions, in its opinion on "Effective water management system: an approach to innovative solutions" in December 2016.

The present document addresses the problem of a too limited application of water reuse in order to contribute to alleviating water scarcity and analyses the modalities of creating an enabling framework for increasing the uptake of water reuse, in particular for agricultural irrigation and aquifer recharge. Setting appropriate minimum requirements together with a risk assessment approach would ensure a level playing field for those engaged in water reuse and those affected, ensure health and the environment are protected and thereby also increase confidence in the practice of water reuse. Acting now by putting in place an enabling framework would contribute to alleviating water stress where it is already a reality today in the EU and also prepare operators and farmers to be ready to act also in those parts of the EU which will experience increasing water stress in the coming years and decades.

1. PROBLEM DEFINITION

1.1. Policy context

This impact assessment analyses the potential of an EU initiative on water reuse **in the context of water scarcity being a serious problem today** and a great concern amongst EU Member States. Europe's freshwater resources are under increasing stress, with a mismatch between the continuously increasing demand for, and the limited availability of, water resources across the whole EU (EEA, 2012[3]). Water over-abstraction, for irrigation purposes but also for industrial use and urban development, is one of the main threats to the EU water environment, while availability of water of appropriate quality is a **critical condition to growth** in water-dependent economic sectors and society in general. Empirical studies find significant macroeconomic affects which vary with the assumed duration and severity of the drought or water scarcity[4].

Water stress already affects one third of the EU territory all year round (EC, 2012[5]). This is no longer only an issue for arid, densely populated regions that are prone to increasing water stress; temperate areas with intense agricultural, tourism and industrial activities also suffer from frequent water shortages and/or expensive supply solutions. While during summer

[3] https://www.eea.europa.eu/themes/water/water-assessments-2012

[4] The overall impacts on the economy due to the 2003 drought have been estimated at a minimum of EUR 8.7 billion (mainly concerning Mediterranean countries, France and the UK), measured as the estimated losses directly resulting from the drought (EC, 2007). Immediate effects of droughts, such as damage to agriculture and infrastructure, as well as more indirect effects, such as a reluctance to invest in an area at risk, can also have a serious economic impact. A 1% increase in the area affected by drought can slow a country's gross domestic product (GDP) growth by 2.7% per year (Brown et al., 2013). In Catalonia, Spain, a simulation of the macroeconomic impact of water restrictions to the Catalan economy for the year 2001 showed that restrictions on non-priority water uses following a drought warning would have led to a loss of gross added-value of about EUR 1.196bn (0.97% of Catalonia's GDP), while extended restrictions in the case of an extreme drought would have caused a loss of EUR 8.079bn, representing 6.52% of the GDP (Gonzalez et al., 2009).

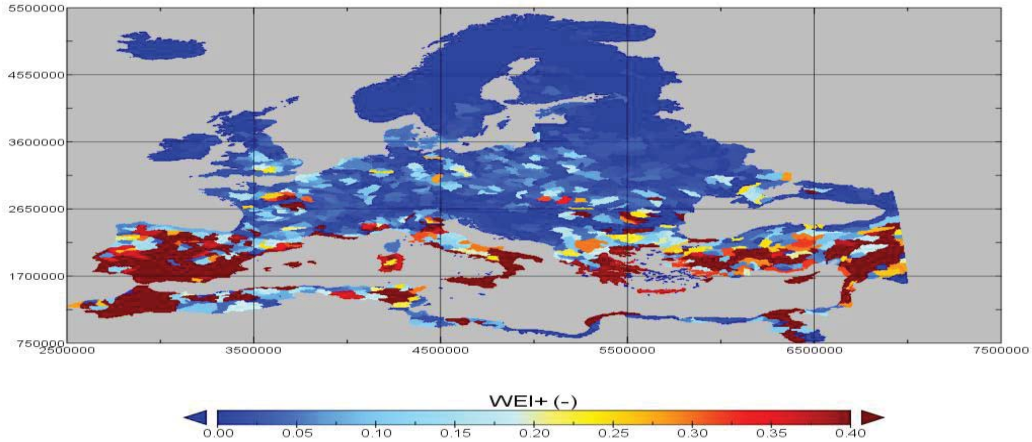
[5] http://ec.europa.eu/environment/water/quantity/pdf/COM-2012-672final-EN.pdf

months this is more pronounced in Southern European basins, water scarcity and droughts are no longer issues confined to southern Europe. Regions in northern European countries, including the United Kingdom and Germany, also face seasonal water stress.

As an effect of climate change, the frequency and intensity of droughts and their environmental and economic damages have drastically increased over the past thirty years: between 1976 and 2006 the number of areas and people affected by droughts went up by almost 20% and the total costs of droughts amounted to EUR 100 billion (EC, 2012). A concrete example related to the droughts of the summer of 2017 may further illustrate the dimensions of economic loss; the Italian farming sector alone was predicting losses of EUR 2 billion[6]. This trend is expected to continue, i.e. the average volume of water annually available as streamflow is expected to decrease significantly in the South of Europe, to slightly increase in the North, with a transition zone in between, where it is expected to remain approximately stable (see Annex 4 for details on the assessment). However, the temporal variability of available water is generally expected to increase, consistent with the general increase in drought and flood hazards projected for Europe (Forzieri et al., 2014; Forzieri et al., 2016)[7]. So, even in the North of Europe there will be a need to better manage water resources and to enable more tools.

As shown in Figure 1, even conservative climate scenarios would subject large parts of the EU territory to significantly reduced quantities of water in rivers.

Figure 1: Water scarcity under a 2 degree climate scenario (Water Exploitation Index, WEI+ is the ratio of consumed water versus availability; in the red areas more than 40% of all annual renewable freshwater is consumed). Source: Bisselink & De Roo, 2017[8] **[6]**



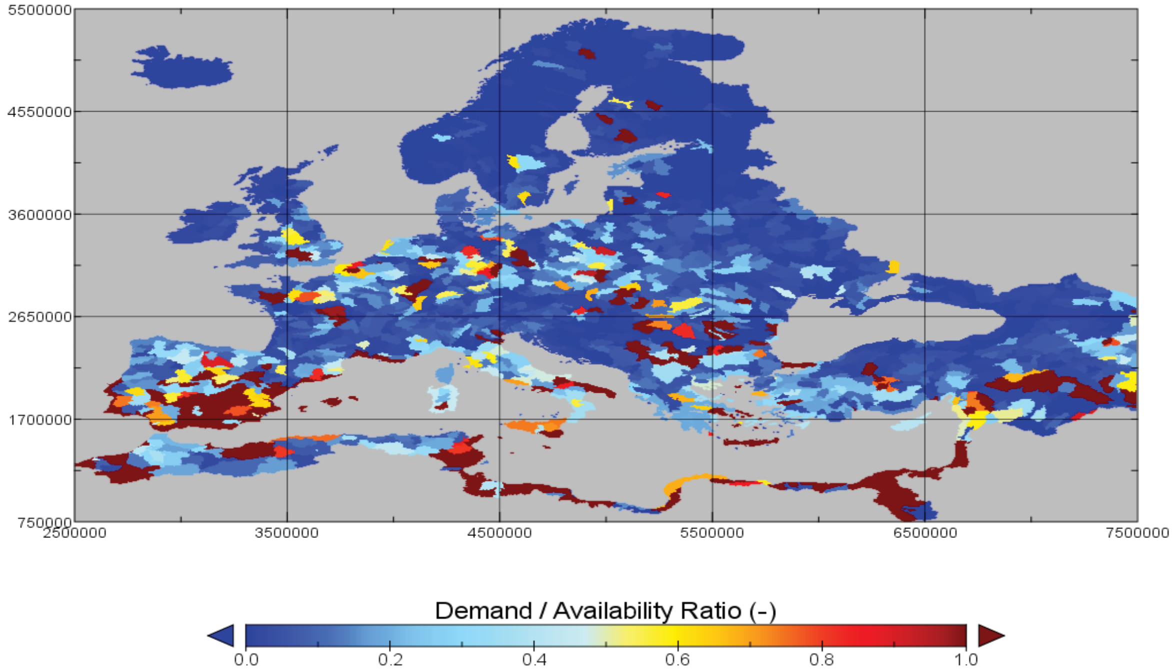
6 http://www.bbc.com/news/world-europe-40803619

7 Forzieri, G., Feyen, L., Russo, S., Vousdoukas, M., Alfieri, L., Outten, S., Migliavacca, M., Bianchi, A., Rojas, R., Cid, A. Multi-hazard assessment in Europe under climate change (2016) Climatic Change, 137 (1-2), pp. 105-119. DOI: 10.1007/s10584-016-1661-x; Forzieri, G., Feyen, L., Rojas, R., Flörke, M., Wimmer, F., Bianchi, A.; Ensemble projections of future streamflow droughts in Europe (2014) Hydrology and Earth System Sciences, 18 (1), pp. 85-108. DOI: 10.5194/hess-18-85-2014

8 Figure 1 and 2 are produced using JRC's LISFLOOD water resources model (De Roo et al, 2000). The 2 degree global temperature increase maps are an average of 5 climate models and simulate the consequences when global temperature increase equals 2 degrees. Within an high emission scenario, without signification climate mitigation (RCP8.5 world) this situation is already reached around 2040. In a milder emission world (~RCP 4.5) this may be reached around 2055. When we would stay within the Paris agreement, we may be getting close to this situation, but without ever reaching it, at least not in this century. The 2 degree assessment includes projections of land use change (using JRC's LUISA system) until 2050, GDP projections, population projections and water demand projections until 2100 (Bisselink, De Roo, Bernhard, 2017). A comparison is made between the ensemble means of the 2oC warming period and the baseline period (1981-2010).

Today's situation can be illustrated using an indicator of water stress due to possible over-abstraction; the ratio of water demand to water availability. Using this indicator, Figure 2 shows how Europe's rivers are already subject to significant pressure from abstractions (see Annex 4 for details on the assessment). The indicator highlights that the challenge is not limited to Southern Europe, but is also an issue in more central parts of Europe.

Figure 2: Water demand divided by water availability. Source: Bisselink & De Roo, 2017.



Farmers needing water for irrigation are obviously affected by this water pressure. Farmers seeking reliable sources of water all year round may have several options for alternative water supplies. These can, for example, include investment in water storage devices, using groundwater reserves, desalination or transferring water from other river basins. In theory alternative water supply options, especially desalination, can deliver unlimited amounts of water. In practice, all the options have a lot of limitations in terms of costs and negative economic, environmental and social impacts. These alternatives have been assessed within the impact assessment of the Blueprint (see Annex 1a for details).

In some countries, farmers may also receive treated waste water from urban waste water treatment plants, which can provide a reliable source of water, less dependent on precipitation and in a quality adapted for this water to be reused for various purposes, e.g. for agricultural irrigation. Water reuse generally has a lower environmental impact than other alternative water supplies and offers a range of environmental, economic and social benefits (Annex 6).

While the evidence demonstrates the seriousness of water stress and its expected evolution, the policy context for water reuse as a contribution to its alleviation has only started to be developed. Another important angle is the impact of water scarcity in one Member State on other Member States via the Internal Market. The differences in concepts, principles and procedures between the water reuse laws of different Member States may impede the free movement of agricultural products irrigated with treated waste water, create unequal conditions of competition, and may thereby directly affect the functioning of the Internal Market.

Water reuse has already been identified and encouraged in provisions of two existing EU instruments, however, these instruments do not specify conditions for the reuse of treated waste water:

- the Water Framework Directive (2000/60/EC, WFD); its Annex VI, part B mentions water reuse as one of the possible supplementary measures;
- the Urban Waste Water Treatment Directive (91/271/EEC, UWWTD): its Article 12 stipulates, as part of the condition on wastewater discharges that "*treated waste water shall be reused whenever appropriate. Disposal routes shall minimize the adverse effects on the environment.*".

In the WFD, water scarcity is a key aspect of water management. This legislation sets inter alia a central goal of attaining good status for Europe's waters by 2015. It requires Member States to characterise the situation of their water in terms of pressures from human activities and set 'programmes of measures' to achieve the good status objective. Those are part of River Basins Management Plans, to be reviewed every 6 years. In 2007, the EU policy on water scarcity and droughts (COM(2007) 414) (WS&D) elaborated on the integration of water scarcity planning into River Basins Management Plans, including the use of appropriate water pricing and ecological requirements for river flows. It spelled out the hierarchy of measures Member States should consider in managing water scarcity and droughts, with priority for water saving and efficiency measures, and with additional water supply infrastructures only to be considered as an option when other options have been exhausted, including effective water pricing policy and cost-effective alternatives. Water reuse is to be considered within such an integrated water management approach. The Circular Economy Action Plan included a number of actions on water reuse (one of which is subject of this impact assessment), including also Guidelines on integrating water reuse into water planning and management in the context of the WFD which were completed in 2016 and are expected to positively contribute.

In 2012, the Commission conducted a series of assessments to check the adequacy of the water legislation and its implementation. A 'Fitness Check' of freshwater policy looked into the relevance, coherence, effectiveness and efficiency of water policy. A major evaluation of the implementation of the WFD was carried out, assessing Member States' River Basin Management Plans (RBMPs). A gap analysis of the Commission's 2007 policy on Water Scarcity and Drought[9] was also carried out, together with an assessment of how vulnerable water resources are to climate change and other man-made pressures such as urbanisation and land use. This included also an assessment of measures introduced by Member States in different River Basins to address water scarcity and droughts. Such measures were, for example, the development of drought management plans, considering additional water supply infrastructure (including water reuse projects) and fostering water efficient technologies and practices. The results showed that the legislative framework was largely complete and fit for purpose. However, the overall objective of the WFD – good status for Europe's waters by 2015 – has not yet been fully achieved, neither the WS&D overall policy objective – to revert the WS&D trends. Furthermore, better implementation and closer integration with other related policies were clearly required, as well as the development of additional tools related to water demand management and water availability.

The few identified gaps were discussed in the Communication "A Blueprint to Safeguard Europe's Water Resources" (COM/2012/0673). As regards the alleviation of water scarcity and reduction of vulnerability, the Impact Assessment of the Blueprint (SWD(2012) 382) assessed a number of measures improving water efficiency and availability (e.g. desalination, water transfers, rainwater harvesting, etc.). Beyond water efficiency measures, water reuse was identified for its cost-effectiveness and its lower environmental impacts compared to other supply options; the need for an EU action to address the barriers to its further development was supported in public consultations (see Annex 2). As a result, the

[9] http://ec.europa.eu/environment/water/quantity/pdf/COM-2012-672final-EN.pdf

Commission announced in the Blueprint it would consider developing a regulatory instrument setting EU-wide minimum requirements for water reuse to improve the uptake of this alternative water supply while maintaining health and environment safety.

A Fitness Check of EU environmental monitoring, which was carried out and presented by the Commission in June 2017, includes an action plan to streamline environmental reporting to be implemented in the coming years[10]. Monitoring needs for the present initiative have been elaborated according to the principles highlighted in this Fitness Check (see more details in Section 7).

The Commission has been discussing water reuse with Member States and stakeholders on an ongoing basis for the last number of years, both on the policy aspects and the development of minimum requirements, taking account of existing national requirements and international practice. The need to address the issue at EU level in the context of alleviating water scarcity is broadly recognised and supported, including by the agricultural sector (see Annex 2).[11]

1.2. Problem definition

The problem this initiative seeks to address is that **although** the practice of **water reuse,** in particular for agricultural irrigation and aquifer recharge**, could contribute to alleviating water stress** in the EU (see projections in Section 1.1), **the uptake of water reuse solutions remains limited in comparison with their potential,** which remains largely untapped. The problem is **relevant for the EU now** due to the **important consequences** of the growing scarcity affecting EU waters **for the environment**, **the economy and society in general**. There is an **important dimension** related to the **proper functioning of the Internal Market for agricultural products** irrigated with treated waste water.

Several factors contribute to the situation concerning water reuse today and any proposed solution to the problem should be seen against this background. Firstly, existing water resources in Europe are not always managed efficiently. There are many situations where access to conventional water resources is insufficiently controlled by public authorities resulting in both over allocation (abstraction permits going beyond available resources, incl. situations where no maximum amount is set in permits) and illegal abstraction (when permits are not enforced in particular because of no monitoring of actual abstractions). The same conventional resources are generally under-priced, as fees imposed on self-abstractions generally do not reflect the environmental and resource cost; the water price in collective systems hardly covers infrastructure costs (cf. below Figure 3). Both issues can be considered as an implementation failure as they contradict WFD provisions regarding the setting of controls on permits, abstractions and water pricing. They can be addressed with e.g. compliance and enforcement actions as appropriate, ensuring a proper implementation of the WFD in Member States[12]. These failures frequently result in a market failure: subsidised uses of water are being practiced, even more detrimentally in situations of water scarcity, which does not reflect their actual cost, leading to a reduction of the economic attractiveness of water reuse projects (if only the latter are considered at their full cost, or if all available

[10] Report "Actions to Streamline Environmental Reporting" (COM(2017)312) and Fitness Check evaluation (SWD(2017)230)

[11] Most recently, Member States expressed support at a meeting of Directors-General for Environment in Tallinn on 23 October 2017. The latest meeting of the Member States' Common Implementation Strategy Ad-hoc Task Group on Water Reuse was held on 6-7 November 2017 a number of Member States and stakeholders expressed strong support for regulation of water reuse at the EU level, pledging for recognising the severity of water stress that they are facing with all accompanying consequences.

[12] In particular the Commission is assessing the updated River Basin Management Plans that Member States were to adopt by December 2015 and will publish an implementation report by December 2018.

options are not compared on equal terms). As a consequence, improper investment decisions made by water users and decision makers in terms of actual costs incurred and environmental impacts, despite water reuse being more advantageous than other measures (e.g. use of drinking water, desalination, lengthy water transfers, on stream storage facilities) in terms of costs incurred and environmental impacts.

Figure 3: Cost-recovery levels in reviewed countries where irrigation water tariffs are in place, and in other southern EU Member States (EEA, 2013)

Country	Cost-recovery levels	Year
Netherlands	99 % (figure including all sectors, i.e. domestic and business users including farmers)	2010
France	O&M costs: 100 % Investment costs: 15–95 % (Average: 55 %)	Arcadis, 2012
Spain (Guadalquivir RBD)	49.78 %	2005
Cyprus	51 %	Arcadis, 2012
Greece	54 %	Arcadis, 2012
Italy	20–30 % (south) 50–80 % (north) Average: 50 %	Arcadis, 2012

Secondly, despite the existing provisions in both the WFD and UWWTD, water reuse has not been systematically and sufficiently considered in integrated water management planning[13]: a) either as a practical solution in the broader water management or in the elaboration and implementation of River Basin Management Plans or b) in the design and location of waste water treatment plants. Cost of adaptation of existing plants and conveying water to places of reuse is generally higher than if taken into consideration at the initial stage of building waste water treatment plants and conveyance networks. The second public consultation identified the distance between treatment plant and irrigation fields and the insufficient consideration for water reuse in integrated management amongst the highest barriers (see Annex 2).

The Regulation on the Hygiene of Foodstuffs (EC) No 852/2004 refers to the concept of clean water but does not include water quality requirements. An accompanying Guidance[14] specifies, amongst others, the use of treated waste water for irrigation; it includes examples of parametric values to ensure the protection of health but their application is voluntary. Potential environmental risks associated with the use of treated waste water for irrigation are not addressed.

Current water reuse practices diverge widely across Member States. In some, water reuse is considered an integral and effective component of long-term water resources management due to severe water scarcity (e.g. Cyprus, Greece, Italy, Malta, Portugal and Spain), while in other Member States water reuse is not practised or water reuse projects are rather limited. An overview of the current situation of water reuse in the EU Member States is provided in Annex 6.

In 2015, the total volume of reused treated waste water in the EU was estimated at 1,100 million m^3/year (BIO, 2015[15]), accounting for 2.4% of the total volume of treated effluents produced or 0.4% of annual EU freshwater withdrawals (237,660 million m^3/year in 2011). The European countries with the highest reuse rates are presented in Figure 4a. However, as presented in Figure 4b, rates even for water scarce Italy, Greece and Spain are much lower than in a number of third countries which have invested a lot in this technology over the last decades. The highest rate is Israel where 87% of treated waste water is presently reused, with a target by 2022 of 90%. This confirms that overall in Europe and even in most European

[13] mainly due to fragmentation of responsibilities for and authorities over different parts of the water cycle; and a lack of communication and cooperation among stakeholders from different sectors involved in the whole water cycle, in particular between water supply (incl. for irrigation) and sanitation stakeholders.
[14] 2017/C 163/01 of 23 May 2017
[15] http://ec.europa.eu/environment/water/blueprint/pdf/BIO_IA%20on%20water%20reuse_Final%20Part%20I.pdf

countries with water reuse being an integral and effective component of long-term water resources management, the potential of water reuse is far from being exploited.

Figure 4a: Effluent reclamation in Europe (Mekorot, 2017)

Country	Cyprus	Malta	Italy	Greece	Spain	Overall in EU
Effluent reclamation rate	89%	60%	5%	5%	12%	2,4%

Figure 4b: Effluent reclamation in third countries (Mekorot, 2017)

Country	China	USA	Australia	Singapore	Israel
Effluent reclamation rate	14%	14%	15%	35%	87%

Compared to the current practice as summarised above, the potential for water reuse in the EU is estimated to be much larger: a volume in the order of 6,000 million m^3/year by 2025 might be achieved in the presence of a better enabling framework and suitable financial incentives at the EU level (BIO, 2015). Reusing the total volume of treated wastewater in Europe could cover nearly 44% of the agricultural irrigation demand and avoid 13% of abstraction from natural sources (Defra, 2011) and could significantly contribute to alleviating water scarcity

The problem as set out above is resulting in an opportunity lost for EU citizens on the whole and economic sectors such as agriculture, tourism, industry, energy and transport (see footnote 2). This may in turn affect economic growth (in the case of reduced production due to water scarcity) or competitiveness (in case of disadvantaged farmers due to differences in input costs or due to unsafe products reaching the markets). The effects of water scarcity in one Member State are also felt in others via the Internal Market and the tightly interconnected European economies through impacts on trade in goods and services as well as investments.

This concerns in particular trade in agricultural products irrigated with treated waste water. The important differences in relation to concepts, principles and procedures between the water reuse laws of different Member States, these differences may in particular impede the free movement of agricultural products irrigated with treated waste water, create unequal conditions of competition, and may thereby directly affect the functioning of the Internal Market. As the intra-EU share of trade in agricultural products by far exceeds the extra-EU share, this aspect is significant. For fruits and vegetables, this amounted to EUR 33.4 billion in intra-EU trade as compared to EUR 4.7 billion in extra-EU trade in 2015.[16]

Furthermore, technology providers in this sector are EU-scale companies[17]. However, differences in standards among Member States can prevent companies benefitting from economies of scale and standardisation, which would support innovation and the development of systemic solutions at lower costs. This was confirmed by the specific consultation of experts in research and innovation (see Annex 8).

1.2.1. Scope of the present impact assessment

The scope of this impact assessment includes water reuse for agricultural irrigation and aquifer recharge; the source of water for such purposes is limited to treated waste water covered by the UWWTD.

This reflects the priority areas as set out in previous Commission documents. In the 2015 Communication 'Closing the loop – An EU action plan for the Circular Economy' (COM/2015/614) and subsequently in the Inception Impact Assessment of the EU water reuse initiative at hand, agricultural irrigation and aquifer recharge were identified as main potential sources of demand for reclaimed water having the greatest potential in terms of its higher uptake, scarcity alleviation and EU relevance: agricultural irrigation as the biggest user of

[16] http://ec.europa.eu/eurostat/statistics-explained/index.php/The_fruit_and_vegetable_sector_in_the_EU_-_a_statistical_overview
[17] https://www.ventureradar.com/search/ranked/Water%20AND%20Reuse/

treated waste water and the links with the Internal Market and aquifer recharge due to the potential cross-border nature of many aquifers.

Beyond the uses analysed in this impact assessment, treated waste water may be used for a wide variety of other purposes. For reference, these are also briefly summarised below and set out in more detail in Annex 6.

Agricultural irrigation is by far the largest application of reclaimed water worldwide and in Europe (Annex 6) and a significant use of water in Europe, overall accounting for around a quarter of total freshwater abstracted. Abstraction for irrigation accounts for about 60% of total freshwater abstraction in Southern and South Eastern Europe, and up to 80% in certain River basin districts (RBDs). Water reuse in agriculture therefore has the highest potential for an increased uptake of water reuse, and thus contributing to the alleviation of water scarcity in Europe.

Artificial aquifer recharge aims at increasing the groundwater potential and it can help prevent saline intrusion in depleted coastal aquifers. The 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). 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). In the first public consultation, aquifer recharge was one of the uses for water reuse most frequently mentioned that stakeholder found appropriate, in particular in order to prevent saline intrusion (see Annex 2). Therefore water reuse for aquifer recharge has been analysed for potential regulation at the EU level but the case for an EU intervention is not deemed proportionate, as set out further in subsequent sections.

Whilst agricultural irrigation and aquifer recharge are in scope, a number of other areas are outside the scope and so not considered further because of various reasons (e.g. they are already covered by other legislation; the risks are being managed effectively and/or are not linked to the internal market).

In terms of investment opportunities, water reuse projects currently suffer from a limited economic attractiveness which is exacerbated by the unclear regulatory framework applying to them and today, the level of investment into water reuse in the EU is limited and far below its potential. This issue is being addressed in the Circular Economy Action Plan which commits to maintain and increase the visibility of existing financial support to investments in water reuse, e.g. with European Structural and Investment Funds. Therefore this topic will not be pursued further in this IA.

A number of actions on improving implementation and enforcement of existing water legislation will be taken independently of this initiative as they are not specific to water reuse. Additionally, in the Circular Economy Action Plan, the Commission committed to develop a series of non-regulatory actions to promote safe and cost-effective water reuse in 2016-2017 (see above).

Water reuse for municipal/landscape uses (e.g. irrigation of public parks, recreational and sporting facilities, street cleaning, fire protection systems etc.) is outside the scope of this Impact Assessment. Local conditions determine both the opportunities and risks, and no significant health or environmental risk has been identified with current practices in the Member States. The risks to the environment are generally very local and they are regulated to a large extent by the existing EU legislative framework (e.g. WFD and UWWTD). Given the visibility of this use to the public, often associated with access restrictions in urban areas where water reuse is practised, the public perception of these risks needs to be adequately managed (see the supporting studies of BIO and AMEC), taking into account the local specificities of these uses. Therefore, authorities in the Member States need some flexibility within the existing framework and no need for further legislative action has been identified.

Direct reuse of waste water from industrial sources for agricultural irrigation is outside the scope of this impact assessment. The quality of industrial waste water is in general very different from domestic waste water in terms of nature and magnitude of pollutants, in particular chemicals. Because of the diversity of pollutants and of the potential harmful effects to both health and the environment of some of these pollutants, these effluents pose specific challenges in terms of safety and treatment technology. As regards the discharge of industrial waste water into the environment, the Industrial Emission Directive only imposes detailed quality requirements (emission limits) on large-size firms in a number of selected sectors. Reuse and recycling of waste water from industrial sources are generally limited to those for industrial purposes in the same or another industry; the conditions for such reuse or recycling are very sector-specific. Best Available Techniques Reference Documents (BREFs) developed under the Industrial Emissions Directive (2010/75/EU) address water use and reuse for most sectors where this is relevant (29 out of 31; e.g. Food, drink and milk industries, Industrial cooling systems, Rearing of poultry and pigs). The drafting of the EU Action Plan on Circular Economy already considered that further promotion of water reuse in the manufacturing industry will be more effectively addressed in the context of the development and review of these BREFs for the relevant sectors.

Reuse of treated urban waste water for industrial purposes is not addressed by the present initiative as its potential for a higher uptake is relatively modest (Annex 6) and rather a local issue that requires a sufficient degree of flexibility at Member State level; therefore, at this moment, any EU level action would not be proportionate.

The reuse of rainwater and grey water is also not included in the scope of this impact assessment. The issue has been addressed in the impact assessment for the Blueprint (see Annex 1a), which pointed out that environmental impacts related to the need of construction and maintenance of the necessary infrastructure for rainwater harvesting may lead to negative energy/treatment/GHG impacts. For water harvesting in agriculture the same negative effects should be taken as those identified for water storage (dams and reservoirs). Furthermore, a previous study[18] conducted in preparation of the Blueprint Communication concluded that EU policy on certification to promote rainwater harvesting and reuse in buildings could lead to significant water savings but would be applicable only for major renovations or new buildings. Therefore, it was found more appropriate to include such promotion in an integrated manner in the development of Best Environmental Management Practices (BEMPs)[19] and in the context of the sustainable buildings policy[20].

As a result the source of water to be reused considered in this impact assessment is only the waste water covered by the UWWTD, that is to say urban waste water defined as "domestic waste water or the mixture of domestic waste water with industrial waste water, subject to the relevant pre-treatment and/or run-off water".

[18] Bio Intelligence and Cranfield University, 2012: Water Performance of Buildings, Study for the European Commission, DG Environment.
http://ec.europa.eu/environment/water/quantity/pdf/BIO_WaterPerformanceBuildings.pdf

[19] https://ec.europa.eu/jrc/en/research-topic/best-environmental-management-practice
In particular rainwater harvesting and greywater recycling are included as BEMP in the sectoral reference document for Tourism (2013) and in the best practice report by JRC for Building and Construction (2012) and Public Administration (2015)

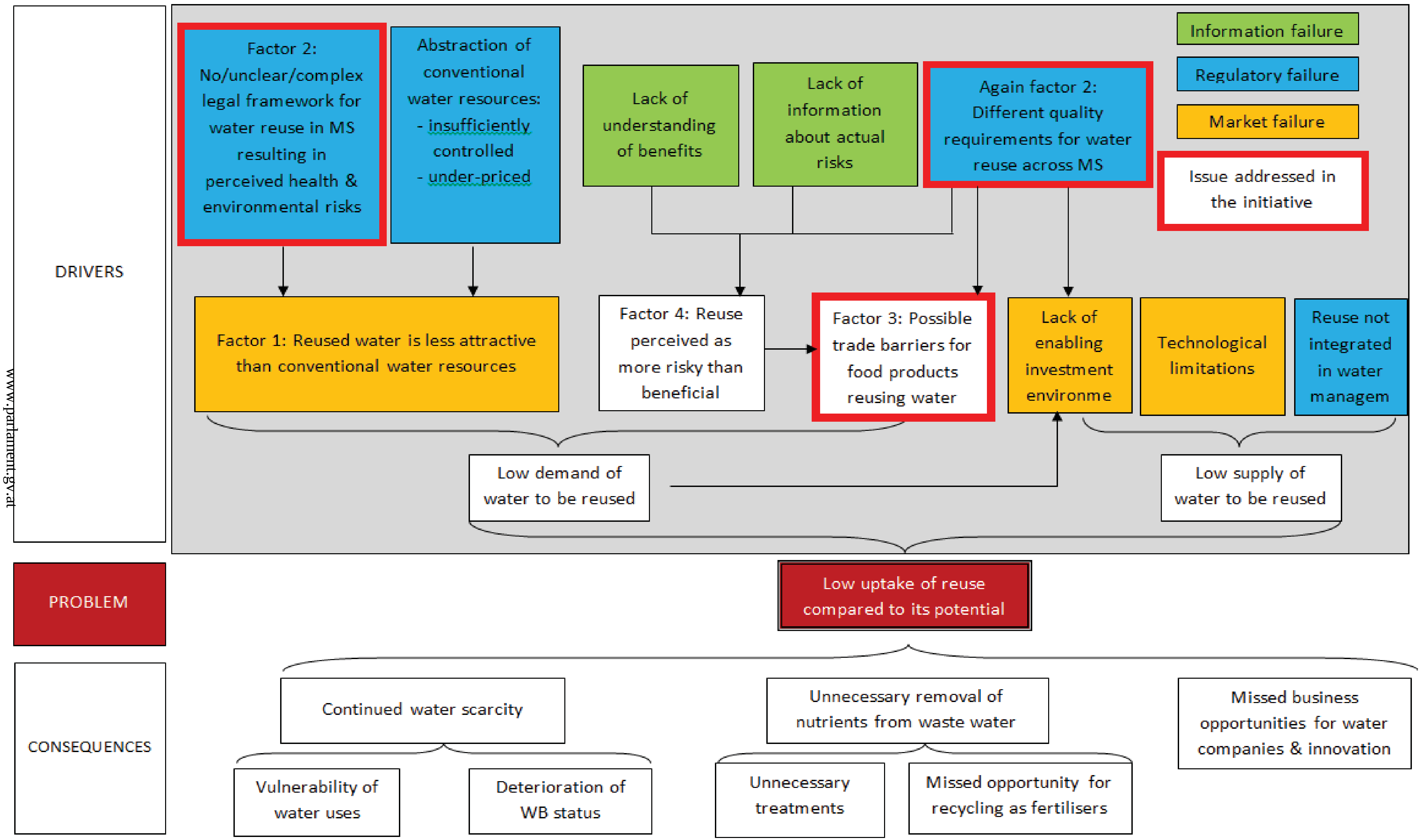
[20] http://susproc.jrc.ec.europa.eu/Efficient_Buildings/documents.html

1.3. What are the underlying causes of the problem?

The **overall problem of "low uptake of water reuse compared to its potential resulting in a suboptimal contribution to alleviate water scarcity" is the result of four factors** discussed below: (1) limited attractiveness, (2) environmental risks and perceived health risks due to varying existing quality requirements or the lack thereof, (3) possible trade barriers and (4) the resulting general view of risks outweighing benefits. However, this initiative is going to address only factors 2 and 3, while factors 1 and 4 are not directly addressed by this initiative.

The problem's underlying drivers and consequences as described in the present section are displayed in a problem tree below. Both this section and the problem tree take as a point of departure the problem definition in the impact assessment of the 2012 Blueprint (see Annex 1a) which already found that: "*The main barrier to expansion of water re-use is the lack of common standards at EU level, in particular in agriculture. While guidelines for agricultural water re-use have been defined by the World Health Organisation, and by different countries, such as the USA and Australia, a uniform solution for Europe is lacking. Establishing standards for the functional operation of the single market is an appropriate EU level response, taking into account EU Health, Agriculture and Energy policies. […] The lack of common health/environmental standards threatens farmers using re-used water to irrigate crops for export within the single market and prevents industry from making long-term investment decisions. It also constitutes a barrier for innovation*."

The second public consultation identified as the main barriers associated with legislation the insufficient clarity in the regulatory framework, administrative burden for water operators, users and public authorities, stringent national quality requirements, and, to a lesser extent, the absence of national requirements for water reuse. The low price of freshwater compared to the price of reclaimed water and the high cost of treatment were also identified among the highest barriers (see Annex 2).



DRIVERS
Factor 2: No/unclear/complex legal framework for water reuse in MS resulting in perceived health & environmental risks
Abstraction of conventional water resources: - insufficiently controlled - under-priced
Lack of understanding of benefits
Lack of information about actual risks
Again factor 2: Different quality requirements for water reuse across MS
Information failure
Regulatory failure
Market failure
Issue addressed in the initiative
Factor 1: Reused water is less attractive than conventional water resources
Factor 4: Reuse perceived as more risky than beneficial
Factor 3: Possible trade barriers for food products reusing water
Lack of enabling investment environme
Technological limitations
Reuse not integrated in water managem
Low demand of water to be reused
Low supply of water to be reused
PROBLEM
Low uptake of reuse compared to its potential
CONSEQUENCES
Continued water scarcity
Vulnerability of water uses
Deterioration of WB status
Unnecessary removal of nutrients from waste water
Unnecessary treatments
Missed opportunity for recycling as fertilisers
Missed business opportunities for water companies & innovation

1.3.1. *Factor 1 – Reused water is less attractive than freshwater*

The WFD, in its Article 9, provides the legal definition of pricing water services and stipulates the principle of cost recovery (including environmental and resource costs) as well as the polluter-pays principle. The available evidence suggests that, at best, tariffs only take account of the financial costs of water treatment and distribution and that few Member States apply direct charges to polluters for the purification of their waste water as well as other activities that impact on water quality, while charging for the resource costs of water abstraction is rare (EEA, 2013). Furthermore, in agriculture, the rather 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). Prices are frequently too low to provide an adequate incentive to the efficient use of both freshwater and reused water.[21] There are measures being undertaken to improve the implementation of Article 9 of the Water Framework Directive so as to achieve better cost recovery[22]. Therefore, the underlying drivers of illegal abstraction and subsidised water prices for freshwater are outside of the scope of the initiative and are not addressed in this impact assessment.

As demonstrated in the Impact assessment of the Blueprint, in areas where water is scarce, reclaimed water can be a cost-effective solution compared to other supply options, especially when all economic and environmental costs are considered. However, even in these cases, reclaimed water is generally found less attractive than conventional water resources.

1.3.2. *Factor 2 – Legal frameworks for water reuse exist only in few Member States resulting in a perceived health risk and environmental risk*

A range of potential risks is associated with reused water which is likely to contain pollutants (organic, microbiological, chemical, etc.). These risks differ by type of reuse and entail contamination of the environment (water resources, soil) and people (direct exposure, ingestion of food products irrigated with reclaimed water, etc.). Health risks are partially addressed by existing legislation concerning agricultural product safety, i.e. the Regulation on the Hygiene of Foodstuffs; however, this legislation does not specify the requirements for treated waste water used for irrigation of agricultural products[23]. Environmental risks associated with water reuse must be considered as well, e.g. 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 over time. Salinity of the water is also a risk to the environment and crops (in case of irrigation). There are also growing concerns over the fate of the wide variety of compounds of emerging contaminants (CECs), e.g. pharmaceuticals, 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. In general such risks can be addressed by applying suitable barriers, the most important barrier being treatment of waste water and applying a risk based approach.

As displayed in Figure 5, these risks can be split into 2 categories associated with water reuse in agricultural irrigation:

- the health risks to consumers of agricultural products irrigated with reclaimed water and placed on the Internal Market; this category of risk includes those to health of animals consuming crops irrigated with reclaimed water;

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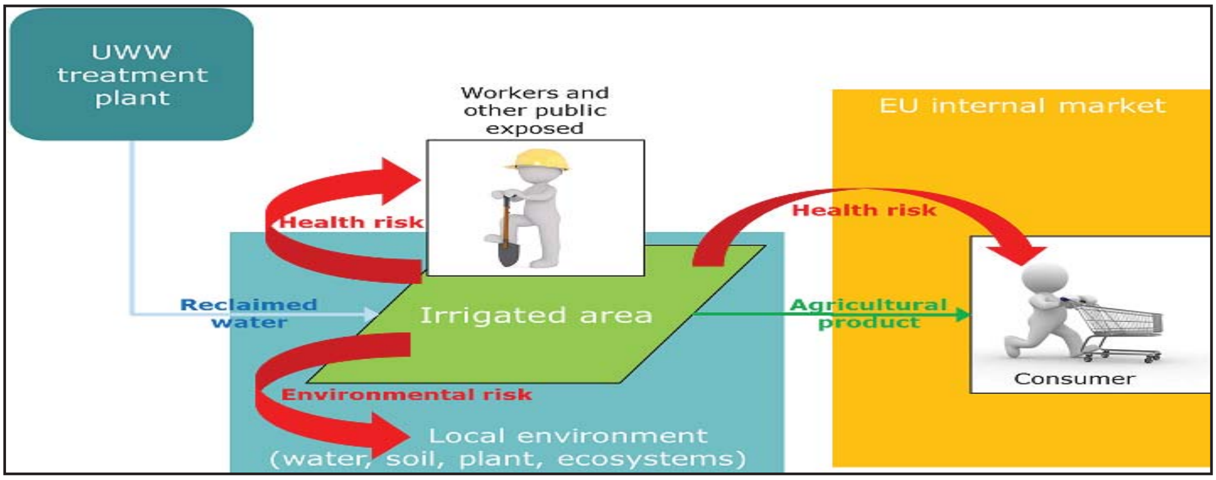
[21] http://ec.europa.eu/environment/water/blueprint/pdf/EU_level_instruments_on_water-2nd-IA_support-study_AMEC.pdf

[22] These measures include enforcement actions launched by the Commission, bilateral meetings with MS on RBMPs, CIS Guidance documents on Art. 9, CIS Peer review process, etc.

[23] Guidance for the implementation of this Regulation introduces some standards for irrigation water, which also covers treated waste water. These voluntary standards do not address all risks, as environmental risks are not covered.

- the health risks to humans exposed to reclaimed water (workers, bystanders and residents in nearby communities) and risks to the local environment (surface waters and groundwaters, soil and depending ecosystems).

Figure 5: Health and environmental risks associated with water reuse in irrigation in the EU



Currently only 5 Member States (Cyprus, Greece, Spain, France and Italy) have developed legislation that sets specific requirements on the reuse of waste water; Portugal has developed non-regulatory standards on water quality. Some other Member States are interested in enabling more reuse of water, but are wary of public perceptions seeing this as a "dirty" technique and so are reluctant to take the initiative on their own to develop a legislative framework. Informally, a number of Member States have indicated an interest in having such a framework, and await to see it developed at European level as announced in the Blueprint as it would be seen as having more standing. Furthermore, whilst 60% of river basins are international, so far, rather countries that do not share river basins as well as those suffering most from water stress have developed their own frameworks.

In the Member States currently with requirements, these vary significantly in their level of stringency as illustrated in Figure 6; none of these national requirements are the same. While there are local specificities, Figure 6 shows that different national approaches and methodologies have been used to arrive at defining requirements to protect consumers' health. In addition to these quality standards to address the potential health risks for consumers, some Member States also apply to some extent a risk assessment approach (see Annex 6 – Overview of MS requirements), however, environmental risks are not addressed adequately and consistently in these existing frameworks. It is to be noted that a risk assessment approach has been introduced on a voluntary basis in the amendment of the Annex of the Drinking Water Directive in 2015 and some Member States (Hungary, the Netherlands and the United Kingdom) have implemented it. The Commission's proposal for a Recast of the Drinking Water Directive introduces the risk assessment approach on a compulsory basis.

This means that the same type of food product (e.g. a tomato), depending on where in Europe it is grown, faces very diverging requirements as to the kind of reclaimed water allowed for irrigation. Nevertheless, these tomatoes are traded across borders in different Member States and are consumed throughout Europe. There is a lack of clarity on how food products are irrigated, resulting in a health risk perception in large parts of the population / consumers / the general public as confirmed by the public consultation outcome (see Annex 2).

Figure 6: Differences in maximum limit values for selected parameters considered in national quality requirements 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[24]
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

Moreover, there is a risk for the health of workers[25]: those working on farms 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 waste water (BIO, 2015). However, general statistics show that there is an increasing trend occurrence of one or more work-related health problems in the sector of agriculture, hunting and forestry, namely 8% of the workforce in 2007 compared to 5% of the workforce in 1999.

In conclusion, even the few existing national quality requirements only attempt to address the health risks to consumers, the second category of risks depicted in Figure 5 (health risks to humans exposed to reclaimed water and risks to the local environment) are not being addressed in an adequate manner.

Therefore, in the Member States where no quality requirements for water reuse are in place, there is a lack of clarity in the regulatory framework to manage health and environmental risks that need to be taken into account when issuing permits for reuse projects. However, in Member States that have set such requirements, especially in terms of management practice, stakeholders say that in practice the conditions are difficult to implement (e.g. conditions on wind force or access control) or too stringent considering the intended use.

This also means that investors find diverging conditions to invest into water reuse production or technology development across Europe, even as regards its use in growing the same type of product, e.g. a tomato. According to the United Nations World Water Development Report 2017, the absence of suitable legal and regulatory frameworks is a critical barrier, creating

[24] Note that this represents the range of different limits for different uses (e.g. crops, irrigation methods). For E. coli, as indicated in RD 1620/2007, the limits are 0 for more stringent values, and 10.000 for less stringent.

[25] General statistics from Eurostat show that there is an increasing trend occurrence of one or more work-related health problems in the sector of agriculture, hunting and forestry, namely 8% of the workforce in 2007 compared to 5% of the workforce in 1999. Moreover, the survey carried out by Eurostat in 2005 found that in the EU27, 8% of workers reported exposure to chemicals, dust, fumes, smoke, or gases (8%). The results of the survey in 2007 show that at least for a quarter of their working time, some persons were exposed to chemical products (15%) and infectious materials (9%).

market uncertainties and discouraging investment into water reuse. This is particularly true as regards irrigation in the EU for which:

- some national legislation[26] requires water quality similar to drinking water whatever the sensitivity of the crop and associated risks are;
- other sources of water used for irrigation (e.g. rivers, private wells) are not subject to mandatory quality requirements.

1.3.3. Factor 3 – Possible trade barriers, i.e. trade bans for food products irrigated with reclaimed water

As identified in the second public consultation, stakeholders in the agriculture sector and the food industry are concerned about potential trade barriers for agricultural goods irrigated with reclaimed water and put on the Internal Market. The Internal Market issue is already significant. In 2015, the EU internal trade flows for fruits and vegetables was seven times bigger in terms of value than external trade: EUR 33.4 billion vs EUR 4.7 billion[27]. Farmers thus depend crucially on intra-EU trade and will not use reused waste water as a source for irrigation unless they know they will be able to sell their products on the Internal Market. The current regulatory framework does not provide a way of demonstrating credibly that risks are properly managed across the Internal Market.

The most extreme form of such a trade barrier would be in the form of a trade ban, when a Member State bans the imports from another Member State of a certain agricultural product irrigated with reclaimed water. This situation arises from diverging regulatory frameworks in place in the different Member States, and also from a certain distrust about safety of reclaimed water (see also the section below). The one case that such trade barriers have been formally imposed within Europe for European producers, was the case of accusations in 2011 regarding possibly contaminated cucumbers from Spain as the cause of a deadly E. coli outbreak (see Box 1 for details). This risk of a trade barrier is considered as an actual and critical risk by a vast majority of stakeholders as shown in particular by the results of the second public consultation, see Annex 2.

Furthermore, some studies[28] suggest that farmers might face market restrictions due to requirements from certification bodies, e.g. Quality Safety Association (QSGmbH) for fruits, vegetables, and potatoes that are irrigated with treated waste water. In addition, some Member States have on several occasions raised the issue of potential market restrictions of agricultural products irrigated with treated waste water, applied by retailers and/or supermarkets[29]. In other words, perceptions about water reuse are claimed to lead some retailers to disadvantage agricultural goods irrigated with reused water.

The Internal Market issue is triggered partially by the problem of low public acceptance.

Box 1: E.coli outbreak and accusations regarding cucumbers from Spain in 2011

The case of the *E.coli* outbreaks which affected 16 countries in Europe and North America in 2011, with more than 4000 reported cases and 53 deaths in Germany, is an example of this situation. The outbreak was blamed on cucumbers irrigated with treated wastewater[30] imported from Spain and several Member States, including Austria, Belgium, the Czech Republic, Denmark, Germany and the UK blocked or restricted the import of Spanish products over concerns that these would have been contaminated during irrigation. It was subsequently

[26] Italy

[27] http://ec.europa.eu/eurostat/statistics-explained/index.php/The_fruit_and_vegetable_sector_in_the_EU_-_a_statistical_overview

[28] https://www.umweltbundesamt.de/publikationen/rahmenbedingungen-fuer-die-umweltgerechte-nutzung

[29] http://www.globalgap.org/uk_en/who-we-are/governance/index.html

[30] See the notification by the Commission through the Rapid Alert System for Food and Feed (RASFF) http://europa.eu/rapid/press-release_IP-11-653_en.htm?locale=en

proven that the source of the *E.coli* contamination was not the cucumbers but rather sprouted seeds from a German farm, and the fenugreek seeds involved were sourced from Egypt[31] . It was estimated that this event cost Spain EUR 200 million per week as orders were cancelled and contributed to cut agricultural income from the Murcia region by 11.3 percent for the 2010-2011 growing season[32]. This has been deterring investment in processing food products irrigated with reclaimed water.

1.3.4. Factor 4 – Reuse perceived as more risky than beneficial

There are several risks associated with water reuse as shown in chapter 1.3.2. No evidence so far could be found of significant pollution/contamination at large scale due to present practices of wastewater reuse in the EU. However, as identified in the Impact Assessment of the Blueprint and confirmed in further consultations on water reuse, there is low public acceptance of reuse solutions and even strong opposition to allowing reclaimed water as a source for drinking water. This is due to misconceptions on what 'reclaimed water' means and a lack of knowledge about actual health and environmental risks.

The absence of a clear regulatory framework is also seen as a cause for a lack of confidence in the health and environmental safety of water reuse practices. There are existing regulatory standards concerning agricultural product safety, however, they do not explicitly regulate requirements for treated waste water for agricultural irrigation, hence there is still a sense of unease amongst consumers about food that has been irrigated with reused water.

Findings from the literature on the acceptability of water reuse amongst producers and consumers are mixed. There are many factors which play a role in its acceptance, the most important of which are the extent of "disgust" over the concept, the use for which recycled water is intended, perceptions of risk from recycled water, the sources of recycled water, choice between recycled and fresh water, trust of authorities and knowledge, attitudes towards the environment, the cost of recycled water and sociodemographic factors (Po et al., 2004). Furthermore, the degree of public acceptance is affected by many factors including the political context of a country (Marks, 2005), local history, the recycling terminology used with the public, the degree of public involvement in strategy development, the threat of alternatives, such as dams, river development or ocean outfall, the degree to which potable recycling is pushed as the primary option, the "not in my backyard" phenomenon, the degree and nature of education provided (Queensland Government, 1999).

The perceptions of risks from the water reuse related to health, foremost among peoples' worries are the safety of their children (Sydney Water, 1999). Water recycling can be more easily accepted in areas with water shortages (Dishman et al., 1989). The acceptability of recycled water decreases as the use moves from public areas (e.g. irrigation of parks) to house (gardening) or to more personal uses, due to risk perception (ACIL Tasman, 2005; Hurlimann, 2005). Socio-demographic factors appear to provide important information as to which demographic groups are most likely to accept recycled water usage. McKay and Hurlimann (2003) predicted that the greatest opposition to water reuse schemes would be from people aged 50 years and over. Such findings on age are also reported by Tsagarakis and Georgantzis (2003) who also found that educated people were more willing to use recycled water.

At the same time both the general public and regulators appear to be insufficiently aware of the benefits of water reuse. In addition to the most obvious benefits (mitigation of economic risks related to water scarcity, conservation of the aquatic environment, cost savings for utilities), there are a host of indirect benefits that stakeholders seem rather unaware of (e.g.

[31] See report by EFSA: http://www.efsa.europa.eu/en/supporting/pub/en-176
[32] See articles: http://www.reuters.com/article/us-germany-ecoli-idUSTRE74S12V20110531 and http://www.foodsafetynews.com/2012/07/spanish-produce-paid-a-price-for-europes-o104-outbreak/

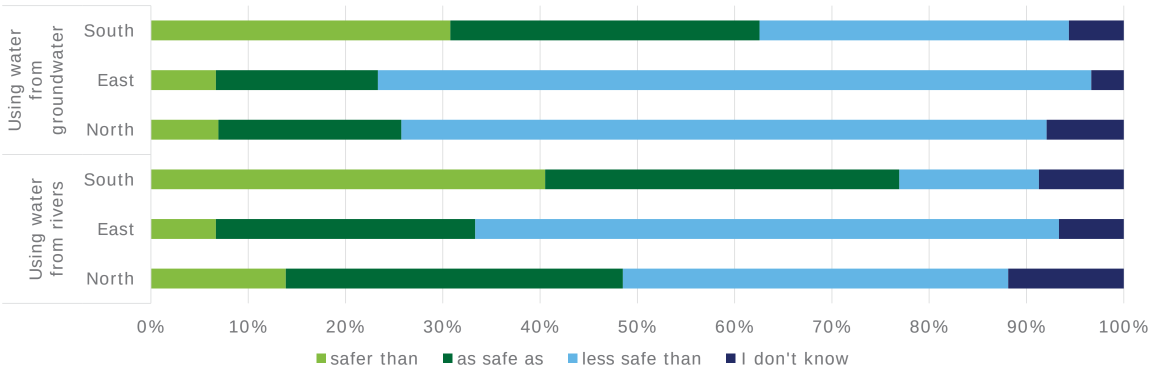
energy and carbon savings, reduced costs and environmental impacts associated with synthetic fertilisers, local economic development).

The second public consultation provided evidence for the lack of consumers' trust in water reuse as it identified this phenomenon as one of the most significant barriers (85% of the respondents perceived this barrier as at least medium and 63% as high). At the same time a large majority of respondents considered that treated wastewater is at least as safe as river water as a source of water for agricultural irrigation or for aquifer recharge (30% even considered it safer; see Annex 2). Furthermore, results of the second open public consultation demonstrate a significantly larger share of respondents from Southern EU Member States consider reused water as at least as safe, independently from the source of water it is compared with.

- In comparison to groundwater: 65% of respondents from Southern EU Member States also consider reused water as at least as safe, while 70% of respondents from Northern and Eastern EU Member States consider reused water as less safe than groundwater,
- In comparison to rivers: 80% of respondents from Southern EU Member States perceive reused water as at least as safe (with half of them considering it even safer), compared to 55% of respondents from Northern EU and only a third of respondents from Eastern EU Member States.

There is larger consensus between respondents from Northern and Eastern EU Member States about the opinion that reused water was less safe than groundwater, in comparison to water sourced from rivers, which remains more controversial within each of these EU regions (see Annex 2).

Figure 7: Safety perception – comparison between Southern EU, Northern EU and Eastern EU Member States in the reuse of water for agricultural irrigation



As a result, this information failure leads to reluctance to consider reuse as an alternative water supply option when relevant and cost-efficient. The Impact Assessment of the Blueprint already identified this issue as well as the opportunity to develop awareness raising campaigns and advisory services. A number of actions committed by the Commission in the Circular Economy Action Plan (e.g. promotion of safe and cost-effective water reuse, including support to research in further characterisation of emerging risks and to innovation with demonstration projects) and a communication campaign are expected to improve the provision of reliable information and rectify misperceptions of benefits and actual risks by stakeholders and citizens. Additionally, studies show that public trust in water reuse is strongly affected by personal experiences and trust in water reuse organisations and regulatory authorities[33]; it is in general specific to the local situation of water resources and

[33] FP7 project DEMOWARE report: http://demoware.eu/en/results/deliverables/deliverable-d5-2-trust-in-reuse.pdf

management and better addressed at Member State level. Complementary to the above actions, there are ongoing national or local information campaigns that inform about the water reuse practice, e.g. in Spain, when a park is irrigated with treated waste water the relevant information is available to the public at the park entrance.

This information failure will not be addressed in this initiative, apart from providing information to the public on water reuse. However the absence of a clear regulatory framework is addressed, which is an underlying driver and a cause of this lack of confidence in the health and environmental safety of water reuse practices.

1.4. How will the problem evolve, all things being equal?

The current situation and future projections for water availability are set out in section 1.1 above; while water stress is present in many parts of Europe already today, the **past trends in water scarcity are expected to increase in frequency and intensity of droughts and their environmental and economic damages are expected to continue**. This later trend is mainly due to climate change. At the same time, the current state of a mix of absent and un-coordinated national legislation and approaches would continue, resulting in the continuation of related barriers and little incentive to apply water reuse.

An improved implementation of the existing EU water policy framework, especially as regards water pricing and control of abstractions, could positively influence the uptake of water reuse, however, very likely much below its potential for development and benefits to the economy and the environment (BIO 2015). According to the Blueprint, which was based on the 2009 River Basin Management Plans, only 49% of these Plans[34] intend to change the water pricing system to foster a more efficient use of water. The barriers to water reuse related to inadequate water pricing are therefore unlikely to change significantly.

It is likely that additional Member States would adopt their own water reuse standards in the near future (e.g. Malta already has plans to develop its own standards). In those Member States, such new standards are expected to provide more clarity to the stakeholders on the required measures to manage health and environmental risks associated with water reuse. However, in the absence of further EU action specific to water reuse, uncertainty on how to apply the existing EU water legislation to manage risks of water reuse projects would persist in the other Member States, while in the countries with the highest stringency of water reuse standards (France and Italy), the situation is likely to remain unchanged in future years, i.e. very few new water reuse projects.

Water reuse technologies are evolving relatively quickly, therefore a number of the technical barriers identified are likely to be solved within the next ten years, either as a result of research and development work conducted by the water industry or of publicly funded research programmes. The evaluation and management of risks associated with emerging pollutants is, however, a very complex issue and may require more significant efforts.

Finally, it is unlikely that national regulators can co-ordinate a harmonisation of their regulatory requirements. A risk of potential trade barriers for food products irrigated with reclaimed water would continue to persist hand in hand with the low public acceptance of water reuse solutions. Consequently, the problem of the low uptake of water reuse would intensify, and in particular in areas of Europe where water scarcity increases (see projections of water scarcity in Section 1.1).

[34] An assessment of 2015 RBMPs is ongoing, hence this figure will very likely change, as there are developments in some Member States.

1.5. Who is affected and how?

The currently limited uptake of water reuse affects in particular the environment, economic sectors, national/regional/local authorities, and European citizens and consumers.

Concerning the **environment,** increasing trends in water scarcity exacerbated by climate change together with a low uptake of water reuse affect water resources which are over-exploited by abstractions, in particular for irrigation, and also water-dependant ecosystems which are not left with the necessary amount for them to thrive. In particular, coastal areas of water-scarce regions where treatment plants discharge their effluents to the sea are affected by the wastage of limited freshwater resources. However, it has to be stressed that discharge of treated waste water to rivers can be a major component of river flows in dry seasons, up to 80% in extreme cases (Drewes, 2017[35]). In these cases reuse can also result in reducing the flow beyond critical limits and have a negative impact on the river and associated ecosystems, despite the fact that unplanned reuse takes already place *de facto*. The quality of water resources is also affected by unnecessary discharge of nutrients into rivers. In addition, the removal of nutrient in treatment plants, even though it is necessary in sensitive areas to prevent eutrophication of water resources, is energy intensive, hence resulting in higher GHG emissions and the same holds true for the production of chemical fertilizers for agriculture. The lack of a consistent methodology to apply the risk assessment approach results in a potential deterioration of the environment due to potential contamination of soils with metals, CECs, etc. These environmental impacts clearly have a local dimension, however, 60% of the EU's rivers run across borders of Member States (and non-Member States). If waters are low in an upstream Member State, less water will reach any downstream Member State. Action taken by a single or few Member States is therefore not sufficient in relation to quantitative aspects of water management and so these environmental problems can be cross border.

A number of **economic sectors** are highly dependent on water supply, in terms of availability and quality, such as agriculture (see also Annex 3a SME test), the food industry, the power generation industry (e.g. for cooling processes and hydropower), tourism and the recreational industry (e.g. golf courses), chemical, textile, pulp and paper industries and mining. A lack of water reuse in the regions affected by water scarcity and related restrictions, e.g. bans to use freshwater for certain types of uses like agricultural irrigation, both negatively affect their production and increase costs. The water industry and their technology providers are affected through foregone business opportunities in the area of treated waste water reuse. These opportunities appear large as the global market for water reuse is expected (Global Water Intelligence, 2015) to be fast-growing in the coming years. Between 2011 and 2018 capital expenditure on advanced water re-use was estimated to have grown at a compound annual rate of 20% as the global installed capacity of high quality water re-use plants grows from 7 km^3/year to 26 km^3/year. The limited uptake of water reuse technology negatively impacts the potential for further innovation, demonstration and market development for innovative technological and non-technological (organisational, managerial, governance) solutions for water reuse whose market uptake can be negatively affected by the present legislative framework.

From the perspective of **National/regional/local public authorities,** as alternative supply options are generally more costly (considering both capital and operating costs, see Figure 8), the limited development of water reuse tends to render more costly the reduction of water scarcity and implementation of the River Basin Management Plans. It also represents missed

[35] http://ec.europa.eu/environment/water/pdf/Report-UnplannedReuse_TUM_FINAL_Oct-2017.pdf

cost saving opportunities, e.g. by reducing drinking water supply production needs and associated costs.

Figure 8: Cost comparison of different water scarcity solutions

Solution	Typical capital cost/ m³/d of capacity	Typical operating cost/m³ produced	Notes
Shallow freshwater aquifer	$3	<$0.01	10m depth 10,000 m³/d
Deep freshwater aquifer	$7	$0.07	200m depth 10,000 m³/d
Brackish water desalination	$480	$0.29	10,000 m³/d
Long distance transfer	$3,000	$0.15	500 km long; 100 m elevation; 2 million m³/d capacity
New reservoir & conveyance	$1,700	<$0.01	250,000 m³/d output with 20 km conveyance
Indirect potable reuse	$800	$0.45	50,000 m³/d facility with UF, RO and UV – water returned to aquifer
Membrane seawater desalination	$1,200	$0.47	100,000 m³/d capacity
Thermal seawater desalination	$1,500	$0.57	300,000 m³/d capacity
Shipping water by bladder	$60	$1.50	10000 m³ bladder to port unloading facility 50 km away
Shipping water by tanker	$120	$1	100,000 m³ tanker travelling 500 km with bulk water loading and unloading facilities

For European citizens and society at large, the inefficient management of water resources results in reduced water availability which, in areas of water scarcity and drought, has a direct negative impact upon the EU economy and citizens. 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. When there are important differences in relation to concepts, principles and procedures between the water reuse laws of the Member States, these differences may impede the free movement of agricultural products irrigated with reused treated wastewater (see above Box 1 on the E. Coli outbreak), create unequal conditions of competition, and may thereby directly affect the functioning of the Internal Market. Furthermore, a 1% increase in the area affected by drought can slow a country's gross domestic product (GDP) growth by 2.7% per year (Brown et al., 2013). For **consumers**, the lack of European minimum requirements for water reuse leads to mistrust and misunderstanding about how agricultural products are irrigated and whether they are safe if irrigated with reclaimed water.

2. WHY SHOULD THE EU ACT?

The problem this initiative sets out to address is relevant at EU-level, as concluded in the analysis in section 1 above. With this initiative, EU action would aim at enabling a cost-effective waste water reuse for agriculture, while ensuring a high level of protection of health and the environment and contributing to the well-functioning of the Internal Market. Thereby, the main problem drivers (diverging requirements in Member States, resulting in potential trade barriers for agricultural products irrigated with reclaimed water, as set out in the problem definition, section 1.3) would be addressed.

Acting now by putting in place an EU-level enabling framework would allow contributing to alleviating water stress where it is already an important reality today in the EU and preparing operators and farmers to be ready to act also in those parts of the EU which are expected to experience increasing water stress in the coming years and decades, thereby helping prevent the situation from deteriorating.

2.1. Competence

The EU competence to take action on water management derives from Article 191 of the Treaty on the Functioning of the European Union related to the protection of the environment:

“Union policy on the environment shall contribute to pursuit of the following objectives:

- *preserving, protecting and improving the quality of the environment,*
- *protecting human health,*
- *prudent and rational utilisation of natural resources,*
- *promoting measures at international level to deal with regional or worldwide environmental problems, and in particular combating climate change.”.*

Since in particular environmental risks of water reuse are not addressed by the Member States, and there is a clear EU dimension to these risks, moreover the issues at stake are directly related to the inefficient use of a natural resource and adapting to climate change, the legal basis for a possible new EU legal instrument would therefore be Art. 191.

In addition, the EU competence to take action on safety of agricultural products irrigated with reclaimed water is linked to Article 169 of the Treaty on the Functioning of the European Union related to consumer protection:

"1. In order to promote the interests of consumers and to ensure a high level of consumer protection, the Union shall contribute to protecting the health, safety and economic interests of consumers, as well as to promoting their right to information, education and to organise themselves in order to safeguard their interests.
2. The Union shall contribute to the attainment of the objectives referred to in paragraph 1 through:
(a) measures adopted pursuant to Article 114 in the context of the completion of the internal market; […]"

This initiative is also expected to contribute to the free movement of goods in the Internal Market.

2.2. Subsidiarity

Any new EU initiative on water reuse needs to comply with the principles of proportionality, taking due account of subsidiarity considerations.

Concerning environmental protection, EU-level action on water management is also justified because 60% of EU river basins are international, shared by between 2 and 19 countries (Danube); action taken by a single or few Member States is therefore not sufficient, for instance in relation to quantitative aspects of water management and cross border water pollution. Moreover, if Member States act alone, the technical barriers to water reuse and associated costs are likely to be unnecessarily high.

EU intervention on water reuse in particular for agricultural irrigation is justified to prevent that different requirements in individual jurisdictions negatively affect the level playing field (e.g. between farmers and growers) and cause obstacles to the Internal Market, especially for primary agricultural products. Additionally, different requirements may also be used as an argument to restrict the import of food products from Member States suspected of having lower requirements, as exemplified in the E. Coli outbreak mentioned above (see Box 1). The current situation does not guarantee a level playing field between food producers of different countries; the current EU regulatory framework does not yet address the specific modalities of agricultural products irrigated with treated waste water. Addressing such barriers is an appropriate EU level response, taking into account EU food safety, health, agriculture and energy policies.

EU action is further justified because different and changing requirements in individual jurisdictions are a barrier to the creation of a level playing field for investments in innovation and for water reuse. It is unlikely that national regulators can coordinate a harmonisation of their regulatory requirements as the number of Member States involved is too large and increasing.

The present document seeks to address the overall problem of a too limited application of water reuse resulting in a suboptimal contribution to alleviating water scarcity and analyses the modalities of creating an enabling framework for increasing the uptake of water reuse for agricultural irrigation. Therefore as already defined by the Blueprint in 2012 in order to ensure the safety of water reuse practises minimum requirements are developed, which would need to be met if water reuse was practised in a Member State. Given the environmental legal basis of a potential future instrument on water reuse, the instrument would allow those Member States with more stringent national standards than the EU minimum level to keep them in place or those wishing to introduce higher national standards to do so. In this context, at the practical level, it should be noted that the proposed EU minimum criteria have been developed together with Member States, stakeholders and the scientific community over the past years and are broadly supported.

It is worth noting that in addition to the targeted discussions between the Commission, Member States and stakeholders over the past years, also the public consultation activities showed strong support for EU measures. In the first public consultation this was considered by almost all of those who expressed an opinion as a legitimate component of EU action. More than 90% of respondents from Member States with quality requirements for water reuse indicated that legally binding EU level minimum requirements would be effective or very effective for ensuring environmental and health safety of water reuse. The second public consultation confirmed a very strong support to defining minimum requirements for water reuse in agricultural irrigation and aquifer recharge, going much beyond Member States and stakeholders in regions where this is currently a developed practice (see Annex 2).

A proportionality analysis of potential EU action on aquifer recharge demonstrates that there is a clear local relevance of this practice, with a very limited cross-border dimension across the EU territory. In addition, the Internal Market dimension which has been identified as a crucial aspect for agricultural irrigation is lacking in the case of aquifer recharge. Finally, the conclusions of the JRC technical report suggest that no minimum requirements at EU level could be developed (see Annex 7). On this basis, this analysis leads to the conclusion that an EU intervention would not be proportionate. The development of an EU Guidance is proposed, however, legally binding intervention in this area should remain the competence of the Member States. A more detailed analysis is included in Annex 11.

3. OBJECTIVES – WHAT SHOULD BE ACHIEVED?

3.1. General objective

The general objective is to contribute to alleviating water scarcity across the EU, in the context of adaptation to climate change, by increasing the uptake of water reuse for agricultural irrigation wherever this is relevant and cost-effective while ensuring the maintenance of a high level of public health and environmental protection.[36]

This general objective corresponds to the overall problem which motivates this initiative (see section 1.2). Clearly, water reuse will not by itself solve water scarcity, but the purpose of this initiative is to make sure that it can be more widely used and is safe.

[36] This general objective was identified as a priority in the Blueprint in 2012 and the Circular Economy Action Plan in 2015.

This general objective is fully in accordance with the 7th Environmental Action Programme[37] and, at the global level, the United Nations' 2030 Agenda for sustainable development and the achievement of the sustainable development goal n°6 "Ensure access to water and sanitation for all", in particular as regards the two following targets:

- *By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally;*
- *By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.*

3.2. Specific objectives

The specific objectives aim at managing water resources more efficiently through creating an enabling framework for and establishing a common approach to water reuse in agricultural irrigation across the EU. They relate to the concrete factors 2 and 3 that together drive the overall problem (see section 1.2). The goal is to promote water reuse as one of a range of measures to alleviate abstraction pressure on vulnerable water resources in the context of adaptation to climate change and integrated water management by setting a common methodology so as:

- To ensure that water reuse practices in the EU are safe both to health and the environment;
- To promote water reuse as a way of providing a secure source of water for irrigation where it is economically advantageous to do so;
- To provide clarity, coherence and predictability to market operators who wish to invest in treated wastewater reuse in the EU under comparable regulatory conditions;
- To stimulate business and innovation in water reuse by EU companies for internal and external markets;
- To provide clarity and confidence to consumers regarding safety of agricultural products irrigated with reclaimed water within the EU;
- To prevent trade barriers for agricultural primary products irrigated with reclaimed water within the EU and thereby facilitating the free flow of agricultural goods.

There are strong inter-linkages between the environmental, trade and public health elements of the objectives. In particular the Internal Market component is a key element of the initiative and a key to its success. Farmers depend crucially on intra-EU trade and will not use reused

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[37] General Union Environment Action Programme to 2020 (Decision No 1386/2013/EU), and more especially its following objectives:

- *"To protect, conserve and enhance the Union's natural capital",* with actions ensuring that by 2020:

  (b) the impact of pressures on transitional, coastal and fresh waters (including surface and ground waters) is significantly reduced to achieve, maintain or enhance good status, as defined by the Water Framework Directive;

  (f) the nutrient cycle (nitrogen and phosphorus) is managed in a more sustainable and resource-efficient way;
- *"To turn the Union into a resource-efficient, green and competitive low-carbon economy"* with actions ensuring that by 2020:

  (b) the overall environmental impact of all major sectors of the Union economy is significantly reduced, resource efficiency has increased, and benchmarking and measurement methodologies are in place. Market and policy incentives that foster business investments in resource efficiency are in place, while green growth is stimulated through measures to foster innovation;

  (c) structural changes in production, technology and innovation, as well as consumption patterns and lifestyles have reduced the overall environmental impact of production and consumption, in particular in the food, housing and mobility sectors;

waste water as a source for irrigation unless they are confident that they will be able to sell their products.

3.3. Operational objectives

The operational objectives are to define common minimum quality requirements for reused water for agricultural irrigation together with a risk assessment framework, complementing existing agricultural product safety standards, which ensure maintenance of a high level of protection and address the risks of water reuse to:

- consumers of agricultural products irrigated with reclaimed water,
- workers and other public exposed to reclaimed water,
- the environment, in particular water resources and dependent ecosystems and soils.

These objectives are strongly supported by the public. Respondents to the second open public consultation considered that specific objectives to be addressed by EU minimum quality requirements for water reuse in agricultural irrigation should be safety of agricultural products placed on the EU market (87% of respondents), protection of water resources and dependent ecosystems (80%), protection of human health of public directly exposed to reclaimed water (75%), protection of wider environment (75%). Other objectives, such as protection of agricultural productivity are by far less supported (see Annex 2).

Such a policy would complement and be coherent (not lowering the applicable levels of environmental protection) with the existing EU legislative framework on:

- water, notably the WFD, the Groundwater Directive, the Nitrates Directive, the Environmental Quality Standards Directive (EQS) and the UWWTD,
- food safety, notably the Regulation on the Hygiene of Foodstuffs.

4. POLICY OPTIONS

4.1. Baseline – "No new EU action"

Under the baseline, the EU would not develop any new regulatory or non-regulatory action specific to water reuse. Consequently, the current state of a mix of absent and un-coordinated national legislation and approaches would persist. The barriers to and lack of proper incentives for water reuse, as described in the problem definition, would largely remain in place, as well as a potential risk of trade barriers to agricultural products irrigated with treated waste water.

This scenario includes, however, a number of actions to improve the implementation and enforcement of existing legislation on water that will be taken independently of the initiative assessed in this Impact Assessment since they are not specific to water reuse (especially as regards water pricing and control of abstractions)[38]. Furthermore, a series of non-regulatory actions to promote safe and cost-effective water reuse in 2016-2017 are committed by the Commission in the Circular Economy Action Plan[39]. These actions aim at improving implementation and enforcement of existing legislation with a specific focus on water reuse. They include Guidance on the integration of water reuse in water planning and management[40] (adopted in June 2016), improved consideration for water reuse in the industry in relevant

[38] In this context, it should be noted that in a number of Member States, important progress in particular on water pricing was made through the related ex-ante conditionality, which made the availability of EU funding (regional and agricultural) contingent upon meeting certain legal requirements of the WFD.
[39] COM(2015) 614 final, Annex I
[40] http://ec.europa.eu/environment/water/pdf/Guidelines_on_water_reuse.pdf

Best Available Techniques Reference documents (BREFs[41]), and increased visibility for support to innovation (through European Framework Programmes and R&I networks) and investments (e.g. European Structural and Investment Funds). The baseline will serve as benchmark for the other policy options defined in this section.

4.2. Design of policy options

This Impact Assessment assesses policy options for agricultural irrigation (Ir), as set out in section 2 above. All policy options directly translate the set of specific objectives of this initiative, as set out in section 2.2 above, into a concrete operational instrument for their attainment. They are all designed to establish comparable regulatory conditions for water reuse projects across the EU and to ensure the maintenance of a high level of public health and environmental protection (see section 3 above), as well as contributing to the proper functioning of the Internal Market by setting minimum requirements. The policy options considered do not set any mandatory waste water reuse targets; the aim is, therefore, to develop an instrument that would enable uptake of treated waste water reuse across the Member States if and when they decide to adopt such a practice.
All options define a common methodology so as to address the two categories of risks described in the problem definition and Figure 5, in the following way:

1) The health risks to consumers of agricultural products irrigated with reclaimed water: These are translated in the options into minimum quality requirements in form of standards and
2) The risks to the local environment (surface waters and groundwater, soil and depending ecosystems) and to humans (workers, bystanders and residents in nearby communities) exposed to reclaimed water: these are translated in the options into minimum quality requirement in the form of a Risk Management Framework.

These two categories of risks are different in nature; however, the policy options propose to address them together in setting minimum quality requirements for water reuse for agricultural irrigation. The variation in the policy options considers the level of stringency of the minimum quality requirements for the safety of agricultural products ('one-size-fits-all' or 'fit-for-purpose') and legislative nature of the proposal (mandatory legal instrument versus voluntary guidance (see for details chapter 4.2.2). All policy options considered include the Risk Management Framework as the only means to address the risks to the local environment and to humans exposed to reclaimed water (see for details chapter 4.2.3).

The options for analysis assume either a new EU legal instrument or an EU-level Guidance. The consideration of the latter non-regulatory approach has been based on thorough consultations with Member-States and stakeholders, and taking into account the recently published Guidance related to the Regulation on the Hygiene of Foodstuffs[42] and international practice. While the mandatory legal instrument (option Ir1 and Ir2) would include only the Key Risk Management Principles as compulsory and an accompanying Guidance would be elaborated with Member States to provide details on the practical application, option Ir3 would include a full Risk Management Framework. These different combinations are summarised below in Figure 9.

[41] https://circabc.europa.eu/sd/a/c2f004b6-4c4b-4bbc-8d7d-37938c6c6390/Water%20reuse%20%26%20recycling%20within%20EU%20Reference%20Documents.pdf
[42] 2017/C 163/01 of 23 May 2017

Figure 9: Policy options analysed

Options		Description
Baseline		No new EU action
Policy options for agricultural irrigation	Ir1	**Legal instrument** ensuring safety of agricultural products with a **"one-size-fits-all"** approach (the most stringent minimum quality requirements set regardless of the food crop category and irrigation technique) **and protection of local public health and of the environment (the Key Risk Management Framework Principles)** - an accompanying Guidance on the implementation of the Key Risk Management Principles to be elaborated together with MS
	Ir2	**Legal instrument** ensuring safety of agricultural products with a **"fit-for-purpose"** approach (minimum quality requirements set depending on the food crop category and irrigation technique) **and protection of local public health and of the environment (the Key Risk Management Framework Principles)** - an accompanying Guidance on the implementation of the Key Risk Management Principles to be elaborated together with MS
	Ir3	**Guidance document** on safety of agricultural products with a **"fit-for-purpose"** approach (minimum quality requirements set depending on the food crop category and irrigation technique) and protection of local public health and of the environment (the Risk Management Framework)

4.2.1. Minimum quality requirements for water reuse to ensure health safety of agricultural products irrigated with treated waste waterm which are placed on the Internal Market

The current EU regulatory framework does not yet in particular address agricultural products irrigated with treated waste water, apart from the limited voluntary requirements set in the Guidance on the Hygiene of Foodstuffs. Potential trade barriers of agricultural products irrigated with reused water are associated with claims and perceptions of health risks to their consumers. The prevention of undue use of trade bans within the EU calls for common requirements set at EU level on the quality of reclaimed water, designed to ensure the safety of the relevant consumer products throughout Europe. This requires a legal instrument setting:

- Minimum quality parameters for water to be reused;
- Monitoring frequencies for these parameters;
- Limit values for these parameters to be complied with at the outlet of the (advanced) treatment plant.

The definition of quality parameters (and their associated limit values and monitoring frequencies) can follow two approaches resulting in a different stringency level. This can be captured in two alternative approaches which can be included in the policy options, the "one-size-fits-all" and the "fit-for-purpose" approach, further detailed below.

→ *Justification of the stringency of the quality criteria*

The JRC report included in Annex 7, namely Tables 2, 3, 4 and 5, defines technical parameters on water quality which need to be respected to a certain minimum level in case treated waste water is reused for the purposes of agricultural irrigation. These minimum requirements were developed in a comprehensive and inclusive process involving Member States and stakeholder experts as well as the scientific community. During the development of the proposal, a tiered approach for consultation was applied by the JRC. In the first tier, the JRC invited a group of selected experts from academia, the water sector and WHO to provide input and comments on the drafting work. In a second tier, Member States were formally informed through the CIS Ad-hoc Task Group on Water Reuse and their comments were taken into account. In the third tier, the specifically requested scientific opinions of the independent Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) and the European Food Safety Authority (EFSA) have been taken into consideration. Wherever the approach diverges from their advice, a justification has been provided. Experts have been consulted to provide comments and input through critical discussion on the JRC document along the process.

The internationally widely accepted approach to develop minimum quality requirements for the safe use of reclaimed water for agricultural irrigation and aquifer recharge is the risk management framework, as recommended by the World Health Organization WHO (2006). These guidelines inter alia establish the level of “tolerable risk” of incurring a disease through water consumption, which has been the basis for standards defined in the Drinking Water Directive (98/83/EC amended by Directive 2015/1787). This risk management framework is already applied in the water *acquis;* it is included in the Drinking Water Directive (Directive 2015/1787 that amends Directive 98/83/EC on the quality of water intended for human consumption). Although the management of health risks is context-specific, the WHO guidelines consider that the overall levels of health protection should be comparable for different water-related exposures. Consequently, this “tolerable risk level” has also been taken into account for JRC’s definition of the technical parameters reflecting the minimum quality requirements on reclaimed water used in agricultural irrigation (detailed information in Annex 7, in section 4.3.1 and the technical background in section 4.4.2). Annex 7 also provides an account of then monitoring requirements as well as of the exclusion of compounds of emerging concern and the sensitivity analysis. It is important to note that no risk assessment has been performed specifically for the establishment of the minimum quality requirements and that the JRC bases its proposal on the validity of the risk assessment conducted by the reference documents taken into consideration, namely the Australian Guidelines for Water Recycling being internationally accepted as a key reference also for the specific EU situation.

4.2.1.1. "One-size-fits-all" approach

This approach requires the same quality for any reclaimed water to be used for irrigation of agricultural products. It responds to the perceived health and environmental risks with the most stringent approach without distinguishing between different needs of food crops and irrigation technique. This approach implies that the required water quality has to be the most stringent in order to prevent any risks of contamination even in the worst-case scenario. This approach is the one adopted in the Italian legislation. This option is based on the quality requirements, as detailed in Annex 7 for the most critical situation (quality class A - food crops consumed raw produced with sprinkling irrigation).

4.2.1.2. "Fit-for-purpose" approach[43]

This approach consists in setting reclaimed water quality requirements that will provide the appropriate level of safety for the crop to be irrigated. It considers contamination pathways from irrigation water to the agricultural products, i.e. to which extent contaminants potentially present in the treated effluent are likely to be transferred to the crop and eventually to affect the consumer of the product. These contamination pathways differ according to crop types and to irrigation methods. Indeed, several factors linked to the use of water in agriculture may influence the risk of microbial contamination of the crops, such as: source of water; type of irrigation (drip, sprinkler irrigation, etc.); whether the edible portion of the crops has direct contact with irrigation water; application of a water treatment by the grower; the timing of irrigation in relation to harvesting; possible access of animals to the source; etc. Water of inadequate quality has the potential to be a direct source of contamination and a vehicle for

[43] Terminology used in scientific literature and UN context

spreading localised contamination in the field, facility, or during transport. Wherever water comes in contact with fresh produce, its quality impacts the potential for pathogen contamination.

In particular, food crops more or less consumed raw (e.g. tomatoes, strawberries) require a more stringent water quality to avoid microbial contamination (e.g. strawberries) than food crops which will be cooked (e.g. potatoes) or crops which are not intended for human consumption (e.g. pastures or energy crops). Similarly, irrigation methods interfere in this contamination pathway as e.g. drip irrigation in orchards does not entail a direct contact of irrigation water with fruits in contrast to sprinkling irrigation.

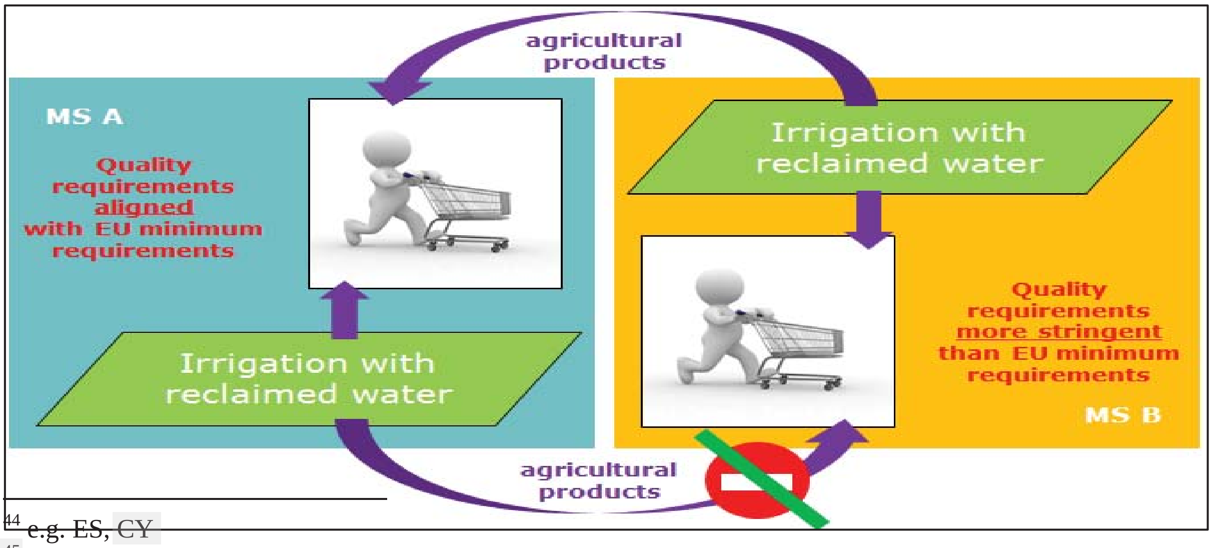
This approach is the one adopted in most of the existing regulations in Member States[44] and international guidelines. This option, like the other options entailing setting some form of minimum quality requirements, is based on the JRC technical report (Annex 7) that was developed to set minimum quality requirements for water reuse. All options would result in a common methodology with minimum quality requirements differentiated against crop categories and irrigation methods; detailed provisions of the options would be developed on this technical basis.

4.2.1.3. Implementation of the requirements

Under both approaches, quality requirements would complement, but not decrease, the ones laid down by the existing legislation, in particular the UWWTD and relevant European Case-Law[45] in particular as regards the quality of discharge effluents. Regardless of the approach chosen, also when complying with the proposal (either legal instrument or Guidance), reclaimed water at the outlet of the treatment plant would need to respect the criteria of "clean water" as defined by the Regulation on the Hygiene of Foodstuffs (852/2004). So consistency with other relevant legislation is ensured in either approach. More information is provided in Annex 3.

The proposal would define a common methodology and set minimum requirements, and any Member State (Member State B in Figure 10) could still adopt or retain more stringent legislation for water reuse in its territory. This proposal would contribute to the proper functioning of the Internal Market through the minimum harmonisation of the requirements and the methodology for undertaking the risk management. Consequently, no trade barriers could be feasible for food products irrigated with reclaimed water complying with the minimum requirements set by the proposal (Figure 10).

Figure 10: Trade of agricultural products irrigated with reclaimed water within the EU



[44] e.g. ES, CY

[45] ECJ Judgement cases C-119/2002, and C-335/07

4.2.1.4. Minimum requirements: regulated at EU-level or recommended by an EU Guidance document

The EU can introduce the minimum requirements in a legal instrument rendering them compulsory to water reuse projects in the EU, or, alternatively, the Commission can develop a Guidance document recommending these minimum requirements for water reuse for irrigation based on the JRC technical report (Annex 7) and would suggest a "fit-for- purpose" approach on a voluntary basis. The Guidance document would build on the international guidelines and long experience developed in third countries (e.g. California, Australia, Israel, USA), and adapted to the specific context of the EU in terms of environmental and social conditions and legislation; in particular it would take stock of experience and best practices developed in the Member States. Such a Guidance document would be developed directly by the Commission, in consultation with Member States and stakeholders (CIS).

4.2.2. Minimum quality requirements to ensure protection of local public health and of the environment – Risk Management Framework

Risks to humans exposed to reclaimed water (e.g. farmers, workers on the fields) and to the local environment are very specific to the local conditions and the design of the reuse scheme; they vary greatly both in their nature and extent according to:

- Hazard, e.g. the quality of raw effluents discharged to the collecting system and entering the treatment plant, mixing with other irrigation sources of different quality, additional contamination during conveyance and storage;
- Exposure, e.g. distance from crop to waterways (especially if these are sensitive areas) or to public spaces, irrigation method, crop type;
- Vulnerability, e.g. to what extent ecosystems, soil and plants are sensitive to pollutants

Because of their intrinsic site-specific nature, these risks cannot be addressed only with a generic set of minimum quality parameters valid for any reclaimed water to be used for agricultural irrigation in the EU. An effective management of these risks has to include a site-specific assessment of those risks, and this assessment would form the basis for the selection of the most appropriate mitigation measures, e.g. additional requirements necessary to ensure a high level of protection of human health and the environment. Despite potentially diverging additional requirements, the methodology to derive these would be harmonised at EU level, thus ensuring a consistent approach across the EU, hence providing ensurance for internal market operators.

The implementation of such a risk management framework is already recommended in some Member States[46] as well as numerous international guidelines and standards (e.g. by the World Health Organisation, the International Standardisation Organisation, the USA Environment Protection Agency). They have been developed in different socio-economic contexts and without taking into account the existing EU legislative acquis which already sets a number of requirements regarding the protection of the environment and health. Therefore, Annex 7 presents the key principles of such a risk management framework both consistent with these international guidelines and adapted to the European context.

With a view to defining comprehensive policy options in this Impact Assessment, two approaches are considered regarding the implementation of such risk management framework:

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[46] Italian guidelines for site-specific risk assessment for contaminated sites (Decreto legislative 152/06) http://www.isprambiente.gov.it/files/temi/siti-contaminati-02marzo08.pdf

- The key Risk Management Framework principles included in a legal instrument and thus made compulsory for operators and other relevant parties involved in water reuse for agricultural irrigation (e.g. competent authorities in Member States, treatment plant operator, farmers) and an accompanying Guidance that would be elaborated with Member States to provide details on the practical application of the key RMF principles;
- The Risk Management Framework recommended in the form of an EU guidance document, based on the key RMF principles.

4.2.3. Key Risk Management Framework principles included in a legal instrument

The first approach would consist of including the key principles of a risk management framework in a legal instrument, as part of the authorisation procedures and conditions of granting permits to any water reuse project in the EU (as described in Annex 3). The key principles would cover the different steps and operators of the water reuse system (urban waste water collection and treatment, additional treatment if any, distribution, storage if any and irrigation at farm level). In practice, the legal instrument would foresee that, before such a permit can be authorised, the applicant of the permit has to perform a thorough identification and assessment of risks specific to the project and its environment. Key requirements for this risk assessment would be laid down based on description of the risk management framework in Annex 7 (page 29).

The legal instrument would foresee that water reuse projects in the EU are regulated within a risk management framework and would set the key principles to be complied with in the permitting procedure. However, competent authorities in the Member States will retain the responsibility of

- Ensuring and checking that the risk assessment carried out by the applicant is appropriate considering the nature of the project and its environment, and
- Reflecting the outcome of the risk assessment in the permit conditions.

In order to ensure a common understanding on the detailed implications of the risk management framework and a consistent implementation across the EU, the Commission would develop a Guidance to translate the key principles into practise and to assist Member States in sharing experiences and best practices, in the existing framework of the Common Implementation Strategy for the WFD (CIS).

4.2.4. Risk Management Framework recommended by an EU Guidance document

As an alternative to making the key risk management framework principles compulsory to water reuse projects in the EU, the Commission could develop a Guidance document on implementation of the full-fledged risk management framework in the existing framework of the Common Implementation Strategy for the WFD (CIS). The Guidance document would build on best international practice within and outside the EU and would be part of the Guidance document for the minimum quality requirements.

5. ANALYSIS OF IMPACTS

5.1. Baseline

Water reuse is not expected to increase significantly over the next years, if no further EU regulatory action on water reuse is implemented, alongside the non-regulatory actions on water reuse proposed in the context of the Circular Economy Package or improved implementation of EU water legislation. Recently collected data shows, if no further EU policy actions to promote water reuse are implemented, it is estimated (BIO (2015) that under a Business As Usual scenario, a volume of around 1,700 million m^3/year could be reached by 2025[47]. This was based on the assumptions that the nationally set water reuse target for Spain (1,200 million m3/year) is achieved by 2018 and no significant increases in water reuse would take place in other Member States in comparison to the current situation.

Therefore, while water scarcity is expected to affect the EU more strongly and widely in the coming decades, resulting in economic losses particularly for those sectors dependent on the secure supply of water, as well as citizens, no significant increase in water reuse is foreseen under a business-as-usual scenario.

It may be argued that such limited water reuse will be developed under the lowest costs possible. Under the current quality standards for Spain it was estimated that a potential for reuse of more than 6,600 million m3/year could be reached below 50 cents per cubic meter, largely exceeding the baseline reuse volume. Therefore it is realistic to assume that the whole volume reused under the baseline scenario would be available at costs below 50 cents per cubic meter.

Water reuse schemes would remain relatively underdeveloped in the EU due to competing demands for investments in infrastructure and - if left to compete on the basis of real costs against subsidised alternatives - due to perceived low returns on investment. Nevertheless, existing reuse schemes have benefited from subsidies to the water sector, but these subsidies could be at odds with the need for cost recovery (as a means to provide adequate incentives for users to use water resources efficiently) and financial sustainability in the water sector if the necessary funding to provide for water related environmental policies is not secured via alternative means. Clearly, as is the case with any investment, for every water investment that requires an outlay of capital, the associated supplementary costs would have to be borne, or shared, by either the state, the service providers, the water end users or the buyers of the products. Given the existing structure and level of pricing for freshwater, as described in the problem definition section (section 1.2), the policy measures to incentivise and support the case for water reuse schemes will support the uptake of water reuse (i.e. boost the demand by increasing the market security and regulatory security for the farmers) and will therefore help with spreading the costs over a larger base.

Moreover, the heterogeneity of national requirements (including the lack of these) concerning the management of health and environmental risks associated with water reuse would continue to constitute a barrier with a potential to affect the EU-internal trade of agricultural products irrigated with reclaimed water (BIO, 2015). Under a scenario of increasing water scarcity exacerbated by climate change, as well as enforcement of water pricing and cost recovery provisions of the WFD (as explained in the problem definition section), the financial costs of securing freshwater supplies are likely to increase over time for agricultural businesses, although few agricultural SMEs bear the cost of wastewater treatment directly (BIO, 2015).

5.2. Analysis of the impacts of the policy options for water reuse in agricultural irrigation

In line with the Commission's 'Toolbox for Better Regulation', as a first step, all the possible impacts have been screened, and on that basis, several of them have subsequently been subjected to a more detailed analysis[48]. The analysis below discusses the **costs** of irrigation

[47] A first rough estimate of the total EU water reuse volume in 2025 was developed for the purposes of this study: under a Business As Usual (BAU) scenario, a volume of around 1,700 Mm3/y could be reached (i.e. total volume of reclaimed water that would be reused in 2025 in the absence of further EU policy actions) http://ec.europa.eu/environment/water/blueprint/pdf/BIO_IA%20on%20water%20reuse_Final%20Part%20I.pdf.
[48] In particular using IA Tools #16-31, see http://ec.europa.eu/smart-regulation/guidelines/toc_tool_en.htm

with reused water and the benefits of it as modelled by the hydro-economic model by the JRC (Annex 4) and some other impacts like administrative burden stemming from the requirement to perform risk assessment under the different options. Environmental and social impacts are also analysed. Wherever relevant, a clear distinction is made between expected impacts for Member States which have national standards in place as compared to those who do not.

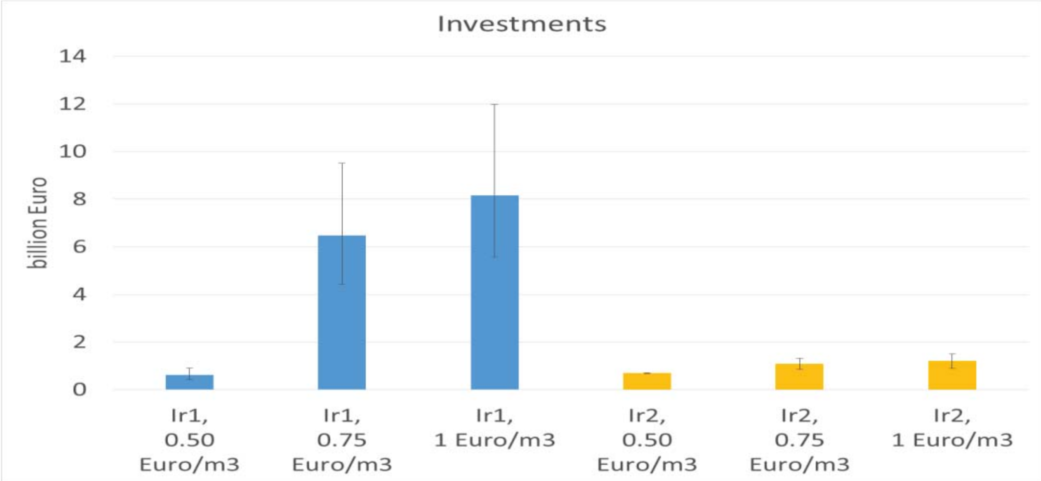
5.2.1. Economic impacts

The cost of waste water reuse is computed as the sum of the cost of: (1) the necessary treatment of waste water for reuse; (2) building infrastructures for water storage and distribution (pipelines and pumps); and (3) energy for reclaimed water pumping from the waste water treatment plant to the neighbouring agricultural areas. The most important cost factor is the transport cost and the underlying model-based assessment has therefore assumed a maximum transport distance of 10 km between UWWTP and the irrigated land, in order to keep costs at reasonable level.

The difference among the options is in the stringency of the water quality requirements, which results in different treatment costs and therefore is a variable cost. The other cost elements are not dependent on which option is chosen. Under Ir1 ("one-size-fits-all") generally higher costs of treatment can be expected than under Ir2 ("fit-for-purpose"), whereby different quality standards apply depending on the use conditions. Ir3 represents an intermediate solution and is expected to end up in a situation where certain countries adopt Ir1 and others Ir2, therefore this option is not examined explicitly in the underlying modelling as costs are falling into the range between the costs of the baseline scenario and the costs of option Ir2. Quantifying the costs of treatment under Ir1 and Ir2 with high certainty is impossible due to the inherent variability of investment and operating costs depending on the initial level of treatment of plants. Moreover, it is impossible to anticipate with high certainty the share of reclaimed water that may need the highest quality standards under Ir1. In order to come to an estimate of the impacts of adopting Ir1 and Ir2 compared to the baseline scenario, it has been assumed for modelling purposes that the treatment would require on an average a depth filtration and disinfection process for Ir2, meaning treatment costs of EUR 0.08/m3 of treated water, while under the Ir1 option, a membrane filtration process would be required to achieve the most stringent standards, meaning treatment costs of EUR 0.23/m3. A more detailed justification of these figures is provided in Annex 4.

The difference in the treatment costs under the two options reflects in a shift of total costs of reclaimed water (including treatment and transport and incorporating investment and operating costs), and consequently in a change in the volumes of reclaimed water that can be distributed at a given cost. In terms of investments, the two policy options Ir1 and Ir2 may be significantly different. Under option Ir2, investment costs of EUR 38/(m3/day) are estimated while under Ir1 these raise to EUR 271/(m3/day). A justification of the underlying assumptions is provided in Annex 4. Under Ir1, an investment of about EUR 600 million in Europe would allow treating about 800 million m3 of waste water yearly with a total cost of reclaimed water below 50 cents per cubic meter, while a slightly higher investment (less than EUR 700 million) would allow treating more than 6,6 billion m3 yearly below the same cost threshold under Ir2. When considering higher cost thresholds, uniformly applying the most stringent water quality criteria (Ir1) in Europe would make investment costs surge in comparison with the fit-for-purpose quality requirements (Ir2).

Figure 11: investments required to treat the available volumes of water at a given threshold total cost, under the Ir1 and Ir2 policy options. Error bars represent the expected range of costs (see Annex 4). Modified from Pistocchi et al., 2018[49].



The direct costs of water reuse would be in principle borne by farmers, who would try to pass these costs on to consumers. However, also today farmers are not bearing the full costs of irrigation because of subsidies, and therefore a similar assumption could be made under the different options. In such a case the costs would be borne by the society at large. Case studies described in Annex 4 highlight a significant willingness to pay of households for a more sustainable management of water resources. This may support the idea that a part of the costs of water reuse could be borne by society/taxpayers and not only by the farmers alone, since water reuse generates additional benefits to society. Nevertheless, there is an economic case to bear the full costs of water reuse under certain circumstances as shown below.

Water shortages appear to be the main reason why farmers would be willing to use and pay for the reused water; the higher the price farmers currently pay for fresh water supplies is, the more they are willing to pay for the recycled water. It is also notable that freshwater supplies for irrigation are not available in all river basins as demand exceeds available supply and so some farmers are currently unable to source freshwater for irrigation, at least with any security of supply. Furthermore, the pumping costs for groundwater, which are increasing with the groundwater levels going down due to increasing water scarcity/droughts or impacts of climate change, could be another significant driver for farmers to opt for reused water.

Therefore, the main argument for farmers to use reused water for irrigation purposes is the fact that it would allow for a secure water supply, including during times of droughts when other irrigation sources may not be available, however, fully respecting the principles of sustainable management of water resources and adaptation to climate change. Existing valuations of the impact of droughts[50] on the overall welfare (farmers and consumers) suggest the benefit of a secure water supply, as allowed by reuse, to be in the order of EUR 500-1000

[49] Pistocchi, A., Aloe, A., Dorati, C., Alcalde Sanz, L., Bouraoui, F., Gawlik, B., Grizzetti, B., Pastori, M., Vigiak, O., The potential of water reuse for agricultural irrigation in the EU. A Hydro-Economic Analysis, EUR 28980 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-77210-8, doi 10.2760/263713

[50] The example of a particular Member State may further illustrate this point. The drought of the summer of 2017 resulted in an estimated loss of EUR 2 billion for the Italian farming sector (see above section 1). Italy currently applies water reuse for irrigation to a very limited extent. Water reuse could, however, cover an estimated 47% of all irritation demand in Italy (see below Figure 10), which would positively contribute to alleviating water stress and avoiding economic loss.

million/year.[51],[52] While this estimation is very rough, it at least shows that, in areas where droughts are (or are likely to become) common, water reuse is clearly also beneficial from an economic point of view. In other words farmers would be willing to pay the limited extra cost of reused water in order to save their crops from severe water shortages and droughts as the benefits would outweigh these limited extra costs.

Under all options those farmers growing crop which are consumed raw, so mainly fruit and partially vegetable growing businesses, would be affected most. As costs would be in EUR/ m3, so proportionate to the amount of water used for irrigation, none of the options would disproportionately affect SMEs. Therefore, no specific mitigation measures would be needed under the different options. More details on how farmers would be affected are included under the SME test (Annex 3a).

A distinction needs to be made between the economic impacts for countries which currently have no national standards for water reuse in place and those who already have some. For the latter, the analysis below takes account of the impacts both for Member States with currently lower standards (ES, EL, CY) and those whose standards are currently more stringent than the proposed EU level (IT, FR). A detailed comparison of the respective impacts is included in Annex 12. The most important economic impacts for Member States aligning with the proposed EU minimum quality requirements could be summarised as follows:

- Unless minimum quality requirements are too stringently set, the legally binding policy options and the Guidance, if followed, will have positive impact on **growth & investments**, as the new regulatory framework, with clearly established minimum quality requirements for water reuse for agricultural irrigation, will boost research and innovation, technological development in the sector, it will incentivise investments and consequently it will be leading to new employment. According to the Territorial Impact Assessment (Annex 9) the development of minimum quality requirements for reused water in agricultural irrigation would have a positive effect of the overall economic growth of all EU regions. Especially the Eastern European regions in the Baltic Sea and the Black Sea and some regions in Greece could potentially benefit with a high positive impact, most other regions would have a moderate impact.
- **Water suppliers**. Operators could face additional investments in waste water treatment, storage and distribution and increased sampling costs in order to comply with the minimum quality requirements while dealing with uncertain demand for the treated waste water from the farmers. It was not possible to estimate to what extent monitoring costs would increase due to the introduction of a risk assessment requirement. It is estimated that the costs for water suppliers would be higher in case of policy options Ir1 due to the necessity to achieve the most stringent (sometimes unnecessary) quality requirements,

[51] A paper on the Po plain in Italy, Musolino et al. (2017) quantifies the impact of droughts on the overall welfare (farmers+consumers) in the order of EUR 500-1000 million/year during drought years. The affected population is more than 16 million persons. This may suggest a cost of about EUR 30-60/person during drought years and is in fact in line with the figures on the willingness to pay provided above. The authors stress that farmers alone benefitted from drought as the price increase was stronger than the production loss in the area. As reuse contributes to water stress reduction in the order of 10%, we may assume an indirect benefit of EUR 50-100 million during drought years, for the Po plain alone. Considering a drought that simultaneously affects an area 10 times as big as the Po plain in Europe, the indirect benefits for the whole of Europe would go back to EUR 500-1000 million during a drought year. Source: Dario Musolino, Alessandro de Carli, Antonio Massarutto, Evaluation of the socioeconomic impacts of the drought events: The case of the po river basin. Europ. Countrys. · 1 · 2017 · p. 163-176 DOI: 10.1515/euco-2017-0010.

[52] During summer 2017, a drought hit the whole territory of Italy causing losses to agriculture, that farmers estimated at least at € 2bn (http://www.bbc.com/news/world-europe-40803619). Notably, also regions traditionally not suffering from water scarcity were hit.

e.g. removal of nutrients that could otherwise be beneficial for the agricultural sector (fertigation). Furthermore, the operators might face higher costs in relation to the compulsory risk assessment approach that is part of Ir1 and Ir2, and for Ir3 if the Guidance is followed by Member States. The alignment with the EU quality standards, including the risk assessment framework would require existing waste water treatment plants to submit an application to amend their permits. If the Member States with relatively less stringent standards were to adopt the proposed EU minimum quality requirements, 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 minimum quality requirements would lead to some burden on businesses to be permitted / registered as required.

- **Functioning of Internal Market, international trade and competition**. Positive impacts on the Internal Market, international trade with third countries and competition would be expected through reduced differences in the requirements used in different Member States. The European producers would rely on a safe and sustainable water supply option leading to a more sustainable agricultural production. In addition, European products could benefit from a comparatively good reputation as minimum quality requirements would ensure adequate safety of the relevant EU products. A similar approach for all EU Member States would contribute towards a more informed and safer consumer choice, with positive impacts for the Internal Market. The impacts on competition with imports from third countries are expected to be neutral. In addition, developing standards at EU level will reinforce the EU stance in international standard setting discussions on water reuse. Common EU standards could serve as a model for third countries, and in particular our bilateral trade partners. Especially those countries facing water scarcity and considering applying water reuse schemes could benefit from the EU approach in addressing potential risks associated with water reuse. This would reinforce bilateral co-operation and standard approximation with key exporting partners of primary agricultural products. The likelihood that negative impacts could be expected as a result of irrigation with treated waste water that is not subsidised, which would then lead to an increase in the cost of agricultural production and as a consequence an increase in the price of agricultural products (thereby rendering these products uncompetitive on the market) is considered a very remote one, because farmers would simply avoid using the costlier irrigation water option. They would instead continue using the already existing irrigation source.
- **Employment**. As a means of better securing water availability, water reuse provides further economic security to agricultural producers, and will build a water reuse expert community to support water reuse business which translates into social benefits. This enables jobs to be secured, created and providing benefits to local communities (EC, 2012) (BIO, 2015); According to the Territorial Impact Assessment (Annex 9), the development of minimum quality requirements for reused water in agricultural irrigation would definitely cause positive effects in all regions with agriculture depending on irrigated land. In more detail, Spanish regions on the Mediterranean coast, Greek regions on the Northern coast of the Aegean Sea and Italian regions around Torino could benefit from a moderate positive effect. All other regions could gain a minor positive impact. Also according to the Territorial Impact Assessment (Annex 9) the development of minimum quality requirements for reused water in agricultural irrigation could improve the public acceptance of reused water, which could open chances for employment, especially in rural areas. Regions with a greater share of employment in agriculture and forestry are likely to be more affected. This would lead to minor positive impacts on most regions. Regions in the North and the South of Romania and several other regions could gain a moderate positive impact if they took up the new options for reusing waste water.

- **Economic impacts for public authorities**. For those Member States with existing national standards that might align with the EU minimum quality requirements, their current systems (quality categories, quality parameters) would not need to be adapted in terms of conceptual design, and it is estimated that 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 could be important, in terms of setting up the administrative system to allow water reuse for agricultural irrigation. For the risk assessment approach, Member States could benefit from the experience with the risk assessment approach introduced by the Drinking Water Directive on a voluntary basis (and is being considered as compulsory in the revision of this Directive). Therefore, only limited additional costs might be expected (around EUR 2,244,176, see Annex 4 for a detailed calculation). However, it is to be noted that the EU will not impose the water reuse practice on those Members States that do not wish to promote it. Reporting under the proposed policy options would most likely entail the use of existing reporting streams such as the reporting under the UWWTD or WFD. If included, separate guidance could be provided in order to define the content and format of information to be reported. There would be modest 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 modest additional burden.
- **Consumers**: The trade of agricultural goods irrigated with reclaimed water would be positively influenced (in terms of levelling the playing field) which could benefit consumers. However, additional costs for water reclamation plants might imply increased costs to water users including farmers, and hence to consumers should the farmers pass on the increased costs. On the other hand a more stable and potentially increased food supply due to reclaimed water and less variation in crop prices might positively affect consumers.
- **Innovation and research**. The introduction of minimum quality requirement and a risk assessment framework under all policy options would 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'[53] 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. It should be noted, however, that innovation and economically viable changes would also take place without adoption of a new legal instrument. 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. The potential market for innovations in water reuse and recycling, through implementing technological solutions and adoption of policy and legislative measures, is expected to grow and develop significantly within and outside Europe, particularly in highly water stressed regions. The Territorial Impact Assessment (see Annex 9) points in the same direction.

[53] Reports/90179/Water-Resources/90193/Water-Reuse/97338/Establishing-a-Robust-Case-for-Final-Effluent-Reuse---An-Evidence-Base also quoted in http://ec.europa.eu/environment/water/blueprint/pdf/EU_level_instruments_on_water-2nd-IA_support-study_AMEC.pdf

- **Benefits for the industry**, EU competitiveness and innovation potential. There is a rapidly growing world water technology market, which is estimated to be as large as EUR 1 trillion 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, and it is on the verge of major expansion and going forward is expected to outpace desalination. 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). Without any policy measures to incentivise / support the uptake of water reuse schemes, it is unlikely that the EU water reuse sector would be maturing at a faster rate. The absence of incentives for further water reuse would lead to no positive impact on competitiveness and innovation related to water reuse technologies and their application to agriculture. Considering the potential worth of this industry, this could lead to a loss of opportunities for the European market to be a leader on this issue.
- **ICT**. Implementing the policy options would be facilitated by advances in the ICT water sector, relevant to remote monitoring, sensors, automation control and decision support systems.

Summary of economic impacts

The above indicated benefits would only be achieved if the minimum quality criteria set are not too stringent and would not result in too high costs. Therefore while Ir1 has in general positive economic impacts, these do not materialise at the assumed cost level of 50 cents per cubic meter, but only at higher cost levels (see next section where it is shown that uptake of this option is calculated to be lower than under the baseline at the assumed cost of 50 cents per cubic meter). This is the reason why in the summary table Ir1 is assessed to have slightly negative impacts.

Figure 12: Summary of economic impacts

2030 (50)	**Option Ir1** **Legal instrument** "one-size-fits-all" approach + RMF	**Option Ir2** **Legal instrument** "fit-for purpose" approach + RMF	**Option Ir3** **Guidance** "fit-for purpose" approach + RMF
Growth & investments	Slightly negative	Positive	Positive, if Guidance followed Neutral, if Guidance not followed
Public authorities	Slightly negative	Slightly negative	Neutral
Sectorial competiveness	Slightly negative	Positive	Positive
Facilitating SMEs growth	Slightly negative	Positive	Positive, if Guidance followed Neutral, if Guidance not followed
Achievement of Internal Market	Slightly negative/neutral	Positive	Positive, if Guidance followed Neutral, if Guidance not followed
Increased innovation & research	Positive	Significantly positive	Positive, if Guidance followed Neutral, if Guidance not followed

Increased international trade & investments	Neutral	Positive	Positive, if Guidance followed Neutral, if Guidance not followed
Specific regions (TIA)	Neutral	Positive	Positive, if Guidance followed Neutral, if Guidance not followed
Consumers	Neutral	Significantly positive	Positive, if Guidance followed Neutral, if Guidance not followed

It is worth noting that an economic safeguard exists in terms of use of water reuse being voluntary. A wastewater treatment plant will only develop the practice (separate treatment and piping infrastructure), if it can sell the water to farmers for irrigation. On their side, farmers will only be willing to pay for the water for irrigation if it is competitive in pricing terms (taking into account also that the security of supply may be higher). As such, option Ir2 will have positive financial impacts for farmers by definition and indeed it is this economic attractiveness that will decide the ultimate level of water reuse. This safeguard is weakened in Option Ir1, where the one size fits all may mean some existing supplies need to be treated to a higher level with resulting higher costs, even if future expansion was always financially advantageous.

5.2.2. Environmental impacts

The main environmental impacts of the proposed policy options include: supporting adaptation to climate change and preserving the quality of natural resources (in particular through the reduction of water stress and nutrient pollution), fostering the efficient use of resources, sustainable consumption and production; and minimising environmental risks.

5.2.2.1. Adapting to climate change and preserving the quality of natural resources

All proposed policy options analysed are expected to contribute to the ability to adapt to climate change and reducing pressure on the environment by shifting the demand from main water supplies towards reused water of appropriate quality for irrigation. Annex 4 provides information on the quantitative model-based assessments available. A short summary is provided below.

Reclaimed water can take up a potentially significant share of the water demand for irrigation in the EU. Figure 13 shows that water reuse has the potential to meet for Spain and Portugal about 20% of irrigation demand, for Italy and France to about 45%, for Greece, Malta and Romania to around 10%. In all other countries, due to the lower irrigation requirements, water reuse is able to meet the whole demand unless irrigated agriculture is relatively too far from wastewater treatment plants (Nordic countries, Slovakia, Bulgaria, Poland).

Figure 13: wastewater availability and potential contribution of reclaimed water to irrigation demand, by EU Member State. Potential contribution to irrigation demand is computed as water that can be allocated, regardless of costs, in the neighborhood of wastewater treatment plants within each country, divided by the total irrigation demand estimated for the country. Source: Pistocchi et al., 2018.

Country	Availability at WWTPs	Total that can be allocated near WWTPs, regardless of cost	Potential contribution of reuse to total irrigation demand
EE	80,710,881	0	0%
LU	42,159,474	291,747	>100%
LT	180,393,800	50,601	32%
LV	351,587,408	104,500	52%
IE	1,199,386,263	1,019,289	>100%
FI	320,255,823	304,968	55%
HR	254,634,919	1,716,665	72%
SI	63,329,276	7,864,075	>100%
CZ	830,070,479	28,279,623	>100%

BE	466,779,792	67,571,968	>100%
MT	3,248,802	3,248,802	11%
AT	831,719,537	78,986,625	>100%
SE	764,770,821	43,679,832	57%
GB	5,785,815,226	185,791,041	>100%
PL	2,028,581,131	59,899,677	70%
BG	1,163,546,557	63,463,880	64%
HU	692,694,899	125,040,578	>100%
NL	961,098,462	264,433,029	>100%
SK	191,797,107	54,429,211	41%
DK	609,431,705	199,487,876	66%
DE	6,759,616,101	624,227,536	>100%
RO	743,414,782	99,146,222	11%
PT	1,278,557,567	660,784,949	23%
FR	4,998,793,967	1,845,451,653	44%
EL	1,153,447,397	417,500,899	9%
IT	9,769,661,947	4,962,268,684	47%
ES	7,114,641,769	3,295,147,922	18%
TOTAL	48,640,145,892	13,090,191,851	

However, not all water available at wastewater treatment plants can be deployed at acceptable costs. Figure 14 shows the amounts of water that can be reclaimed and distributed at different costs (total costs including investment and operation of both water treatment and its transport to farmlands), based on the modelling work described in Pistocchi et al., 2018. Among the largest irrigation demand countries, Greece shows the most favourable conditions for total costs, with the majority of potential water reuse volumes available at reuse costs below 50 cents per cubic meter, followed by Portugal. France is the least favoured, while Italy and Spain are facing an intermediate condition.

Figure 14: Amounts of reclaimed water that can be potentially deployed at different total costs for 27 EU Member States (Cyprus not included due to missing irrigation estimates). "Unmet" represents irrigation demand estimated for the Country, in excess of potentially reclaimed water. Costs shown include treatment costs representative of the Ir2 option. Source: Pistocchi et al., 2018.

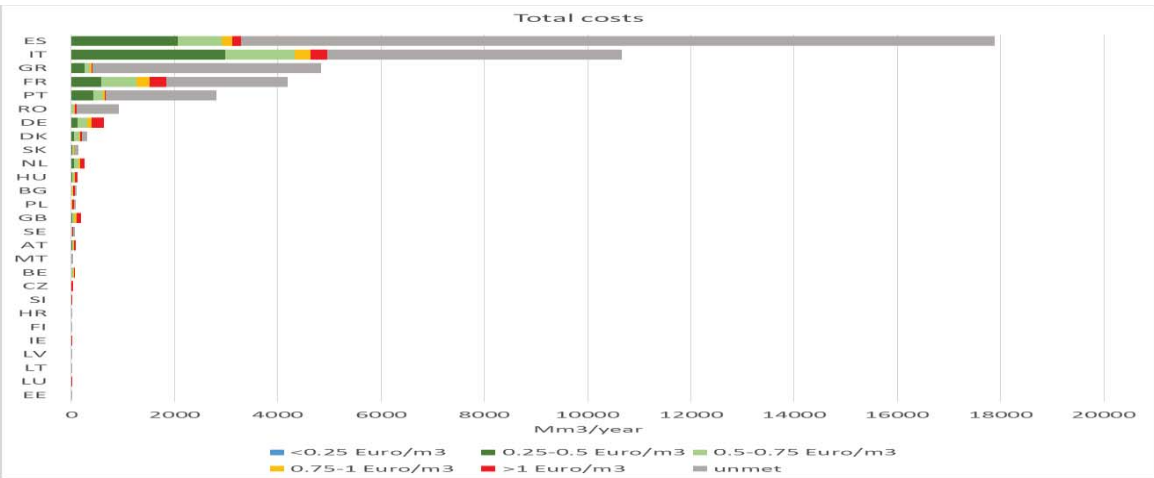


Figure 15 shows the estimated volumes of reclaimed water that can be deployed at costs below 50, 75 and 100 cents per cubic meter with the treatment costs assumed under Ir1 and Ir2. From these figures, it is apparent that under Ir1 less water is available to be reused for irrigation below the cost of 50 cents per cubic meter than under the baseline option. Under Ir1 the minimum quality requirements are too stringent and are too costly to support water stress reduction at the assumed cost of 50 cents per cubic meter. On the contrary, Ir2 allows maintaining costs below 50 cents per cubic meter for a large part of the water available for reuse.

Figure 15: cumulative volumes (m3/year) that can be allocated below or at a given cost in Europe, under « variable quality » and « higher quality » requirements. We refer to total (investment, operation and maintenance) costs. Source: Pistocchi et al., 2018.

	Below EUR 0.5/m3	Below EUR 0.75/m3	Below EUR 1/m3
Under Ir2	6,633,811,238.00	10,438,686,582.00	11,571,593,978.00
Under Ir1	827,229,354.00	8,747,570,594.00	11,028,173,972.00
Baseline	1,700,000,000.00		

The share of agricultural water abstractions is variable across Europe, averaging about 60% in Southern countries, 11% in Eastern countries and 7% in Western countries[54]. A first approximation indicator of water stress reduction potentially allowed by reuse is the % reduction of total abstractions (Figure 16). This ranges from 3.5% in the East, to more than 15% in the North, averaging around 10%[55]. This indicative percentage summarizes a much nuanced picture with significant variability not just among continental zones, but also within countries and regions.

Figure 16: reduction of water abstraction potentially allowed by reuse in different European zones. Based on EEA data, 2017.

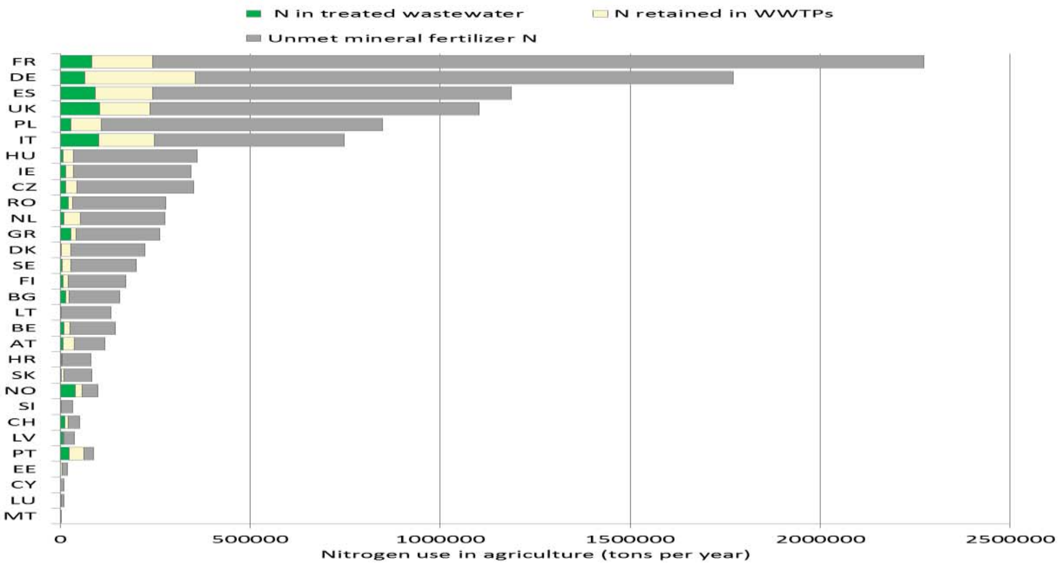
Zone	Total reuse potential, regardless of cost (km3/year)[56]	Irrigation demand (km3/year)	(C) Agricultural share of total abstraction	(A*C/B) Indicative potential % reduction of water absraction
East	0.44	1.37	11%	3.5%
South	9.34	36.2	60%	15.4%
West	3.31	5.21	7%	4.2%

From a water quality point of view, water reuse allows diverting flows of nutrients, from direct discharge to rivers to application to agricultural soils with irrigation. Fertigation (simultaneous application of fertilizers and water to plants) may contribute to reduce nutrient pollution if the application is efficient (i.e., nutrient leaching to groundwater is not increased) and the mineral fertilizers used in agriculture are reduced proportionally to the nutrient flows coming with reclaimed water. Figure 17 shows the nitrogen (N) that can be potentially recovered from wastewater in the different EU Member States. This is a significant amount, and water reuse in itself would enable recovering up to the amounts corresponding to N in treated wastewater. However, the potentials shown in Figure 17 do not take account of the

[54] These percentages are the average of figures for the years 2000s and latest available year collected by EUROSTAT and reported by the European Environment Agency (EEA): https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/assessment-2. Countries are grouped as follows: East: Bulgaria, Czech Republic, Estonia, Latvia, Lithuania*, Hungary, Poland, Romania, Slovenia, Slovakia; South: Greece, Spain, Italy, Cyprus, Malta, Portugal; West: Belgium, Denmark, Germany, Ireland*, France, Liechtenstein, Luxembourg, the Netherlands, Austria, Finland, Sweden, England and Wales, Iceland, Norway, Switzerland.
[55] Arithmetic average 7.7%, irrigation volume-weighted average 13.7%, average of the two 10.7%.
[56] Reuse potential is computed for the three zones by aggregating the volumes shown by country in Figure 13.

costs involved and thus constitute a maximum estimate. The amount of N recovered under the different options would depend on the volumes of m3 of water reuse estimated under the different options. Therefore benefits in fertigation would be highest under option Ir2, but would be practically negligible under Ir1 if we assume a maximum acceptable cost for reclaimed water of 50 cents per cubic meter. Under this assumption, while Ir2 would enable reclaiming about 6.6 billion m3/year of water, Ir1 would enable only 0.8 billion m3/year (Figure 15).

Figure 17: comparison of N from wastewater and mineral N fertilizer. N from water reuse is the load of N in treated wastewater, while the additional N recovery. "Unmet" refers to the amount of mineral N fertilizers in excess of potential N recovery. Source: modified from Pistocchi et al., 2018.



The benefits of reusing water, while clear in principle, depend very much on the local conditions where reuse is to be made. As reuse is meant to reduce irrigation water abstractions from surface and groundwater bodies, in principle it should be implemented only where the benefits from reducing abstractions exceeds the benefits of discharging treated wastewater in the environment. In some cases, especially when treatment standards are high, discharges of treated wastewater may represent a positive input to the receiving water bodies, as they could sustain the flow regime while compensating other possibly existing hydrological alterations. In many cases, however, it is preferable to use treated wastewater in irrigation while reducing irrigation abstractions, because in this way the flow regime of water bodies is least disturbed, and nutrients conveyed by treated wastewater may be taken up by crops[57] instead of ending up in water bodies.

Valuing the benefits that may stem from water reuse is overwhelmingly complex in general terms. One proxy of benefits is the willingness to pay of farmers for reclaimed water, which is extremely variable (for instance, Birol et al., 2007[58] estimate a willingness to pay higher than EUR 0.6 /m3 in Cyprus, while Tziakis et al., 2009[59], indicate less than EUR 0.1/m3 for

[57] This requires that nutrients in reused water are taken into account in the planning of crop fertilization, and that fertilization is efficient. If these conditions are not met, reuse may simply contribute to transfer pollution from surface water bodies (where wastewater is typically discharged) to soil and aquifers where fertilizers may leach.

[58] Birol, E., P. Koundouri, and Y. Kountouris (2007), Farmers' demand for recycled water in Cyprus: A contingent valuation approach, in Wastewater Reuse—Risk Assessment, Decision-Making and Environmental Security, edited by M. K. Zaidi, pp. 267–278, Springer, Dordrecht, Netherlands.

[59] Tziakis, I., I. Pachiadakis, M. Moraittakis, K. Xideas, G. Theologis and K. P. Tsagarakis (2009), Valuing benefits from wastewater treatment and reuse using contingent valuation methodology, Desalination, 237, 117–125.

Crete), see Annex 4 for further details on the range of different studies and estimations for the value of 1 m3 of water. These examples in the Annex highlight the large variability in valuation of water used to reduce water stress, and the uncertainty due to their high case-specificity. In this assessment, based on the above estimations on willingness to pay, the benefit of water reuse can be estimated in the magnitude of EUR 0.5 /m3, which is in the mid-lower end of the cases examined above, and may be argued to represent a first approximation of the combined market and non-market value of water reuse in Europe, provided it contributes to reducing water stress. Therefore it can be argued that there is an economic case for water reuse as in general there would be willingness to pay where water reuse costs do not exceed EUR 0.5 /m3.

According to the above modelling overall a water stress reduction of more than 5% could be achieved in Europe under option Ir2, corresponding to a benefit of about EUR 3 billion/year for the whole EU assuming a willingness to pay about EUR 0.5/m3 for preserving natural flows in rivers and aquifers. This is based on the calculation that Ir2 would enable reusing more than 50% of the total volume theoretically allocated for agricultural irrigation; the total available volume would enable a water stress reduction of approximately 10%. Consequently Ir2 would enable a water stress reduction of more than 5%. Furthermore, most of the alternative water supply options (e.g. desalination, water transfers) are related to the intensive use of energy. Among them the most energy consuming is desalination. If the energy is generated using fossil fuels, this will increase GHG emissions. This is linked to the higher amounts of energy needed to desalinate water (between 3.5 and 24 kWh/m^3 according to the technology), especially with thermal processes. On the basis of an average European fuel mix for power generation, it has been estimated that a reverse osmosis plant produces 1.78 kg of CO_2/m^3 of water, while thermal multi stage flash leads to 23.41 kg CO_2/m^3 and multiple effect distillation to 18.05 kg CO_2/m^3 (Ecologic 2008). Consequently, all proposed policy options would contribute to cutting CO_2 emissions in case the water reuse is used instead of desalination plants, with the "fit-for purpose" options Ir2 having the highest benefits due to the lower energy consumption for the treatment of wastewater for the identified purpose compared to Options Ir1 due to possibly too stringent and unnecessary treatment for some purposes, e.g. more stringent water quality that could otherwise be required for food crops which will be cooked.

Box 2 Example from Spain: it was estimated the desalination installation at Carboneras – Europe's largest reverse osmosis plant - uses one third of the electricity supplied to Almeria province. The more than 700 Spanish desalination plants produce about 1.6 million m^3 of water per day. According to the estimates (1.78 kg of CO_2 per m^3 of water) on CO_2 production from desalination, this translates into about 2.8 million kg CO_2 per day. It can be argued therefore that desalination is contributing significantly to Spain's overall GHG emissions of XX per year, which have increased to +19.4% in 2015 compared to 1990 levels[60]. This may be a foretaste of the dilemmas and choices between different adaptation options that Member States will face in future years as the impacts of climate change are felt increasingly widely (Ecologic 2008).

5.2.2.2. Fostering the efficient use of resources

Policy options Ir2 and Ir3 (if followed) are expected to contribute to the implementation of SDG 6 which sets a target of substantially increasing recycling and safe reuse globally by 2030 insofar as they would increase water efficiency through the uptake of water reuse. Policy options Ir2 and Ir3 (if followed) are expected to foster a more efficient use of water resources, as a clear framework for the water reuse would promote public and user confidence in reclaimed water and provide the possibility to water managers to prioritise various supply options taking into account the local needs of the society and environment. It is estimated that

[60] http://ec.europa.eu/eurostat/web/environment/air-emissions-inventories/main-tables

these two options would result in an increased demand for treated wastewater for irrigation, as the water managers would have a solid basis to encourage/promote the application of water reuse in the planning of the use of water resources in given river basins, as well as farmers would have a confidence in the quality of treated wastewater for the identified purpose. It is anticipated that a regulatory framework on water reuse would result in a decrease of illegal abstractions of groundwater, thus positively impacting the status of groundwater and associated ecosystems. However, for Ir1 the uptake is estimated to be negative at the assumed cost of EUR 0,5/m3 resulting in a supply of water reuse which is lower than the baseline, therefore this would mean less efficient use of water resources.

The assessment undertaken on territorial impacts (see Annex 9) has confirmed that most benefits from setting minimum quality requirements for the reuse of wastewater would mostly concentrate on regions suffering from water scarcity, which are mainly regions also endangered by droughts. In relation to reducing water scarcity the assessment concludes that about 24% of the regions could gain a moderate positive impact situated in the South of Europe (Portugal, Spain, the Mediterranean coast of France, Italy, Greece, Cyprus), in the East of Europe (Eastern Poland, Southern Hungary, parts of Romania and Bulgaria) and in central France and 1% of the regions located in the South of Portugal, in the very South of Italy and Haute-Corse could gain a high impact. The majority of 75% of the regions would face a minor impact. This assessment, however, was conducted only on this option and on the basis of the current situation on water scarcity and did not take account of the likely aggravation of water scarcity due to climate change and is therefore a conservative approach of the potential from water reuse.

Under policy options Ir1, Ir2 and Ir3, if followed, water reuse may result in a more efficient energy use in the water supply and wastewater treatment sector in those Member States adopting the minimum quality requirements. 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[61]. 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 Figure 18 below.

Figure 18: 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, the use of treated waste water for irrigation would require an equivalent or increased level of waste water treatment depending on the policy option. 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 be achieved. Such treatment processes are energy intensive. However, whilst there would be

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

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.

For the sake of modelling, the same energy cost has been assumed for all 3 options and these potential costs savings due to more energy efficient water management could not be quantified. In general it can be concluded that these cost savings would depend on the ability of each option to reduce water stress and proportionate to the reduction the water stress levels. This means that it would be most beneficial under option Ir2, less beneficial but still positive under Ir3, depending on to what extent guidance is followed. Furthermore higher overall energy costs for water management can be estimated for option Ir1 as water stress would even increase under this options in case of the assumed water costs of 0,5 EUR / m3.

5.2.2.3. Sustainable consumption and production

Policy options Ir1, Ir2 and Ir3 (if followed) are expected to significantly contribute to sustainable consumption and production[62] through the recycling of treated wastewater of high quality, which would be otherwise discharged into receiving streams. Considering the effort spent in producing this high quality product, reusing part of this investment for beneficial purposes directly contributes to the sustainable development. While options Ir2 is expected to have positive impacts on the sustainable consumption and production, option Ir1 could represent potential negative impacts due to the removal of nutrients that could otherwise be beneficial for the agricultural sector (fertigation) and it would increase water stress.

5.2.2.4. Minimising environmental risks

Options Ir1 and Ir2 would ensure that environmental risks are sufficiently tackled since a risk assessment would be needed to be performed on a binding basis in all cases water reuse is considered for agricultural irrigation. Option Ir3 due to its voluntary character would only ensure to some extent that environmental risks of water reuse are tackled, depending on to what extent Member States would follow the guidance.

Waste water reuse not only reduces the demands of freshwater, but can also reduce the discharge of nutrients to rivers, other surface water bodies and groundwater. On the other hand, increased uptake of treated waste water 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 and or may lead to human health problems (water-borne diseases and skin irritations). For heavy metals there are concerns that these substances can accumulate 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, by ensuring an adequate type of treatment of the reclaimed wastewater according the areas of application (e.g. sensitive areas or their catchments). Finally, there are also growing concerns over the fate of the wide variety of contaminants of emerging concern (e.g. pharmaceuticals), which are present in sewage, often at trace levels, and which are often

[62] http://www.thesourcemagazine.org/the-role-of-water-in-the-circular-economy/

unmonitored. Evidence remains limited as to how well treatment processes deal with these pollutants.

Figure 19: Summary of environmental impacts (assuming the costs of EUR 0.50/m3)

2030 (50)	**Option Ir1** **Legal instrument** "one-size-fits-all" approach + RMF	**Option Ir2** **Legal instrument** "fit-for purpose" approach + RMF	**Option Ir3** **Guidance** "fit-for purpose" approach + RMF
1- Fighting climate change and preserving the quality of natural resources	Slightly negative	Significantly positive	In the range of neutral to significantly positive depending on to what extent it is followed
2- Fostering the efficient use of resources	Slightly negative	Positive	Neutral-positive
3- Sustainable consumption & production	Slightly negative	Positive	Neutral-positive
4- Minimising environmental risks	Positive	Significantly Positive	Positive-Significantly positive

5.2.3. Social impacts

The same social impacts are anticipated as under the baseline for the Member States without national standards, if they retain the current status (no water reuse requirements in place). In any instance where Member States with more stringent national requirements choose to align with the minimum EU standards, i.e. lower their national standards, some adverse impacts in terms of compromised public acceptance could be anticipated.

By contrast, 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 aligning these with the proposed standards for water reuse in agricultural irrigation would include:

- **Public and occupational health.** In those Member States with national legislation, the proposed policy options are expected to bring little additional benefits with regard to public and occupational health with the exception of Member States with less stringent national standards aligning these with the proposed EU wide requirements. For Member States with no legislation but which adopt the minimum water quality standards, this would provide a framework for protection of human health and safety of individuals/populations. The legally binding policy options and the Guidance if followed would also decrease the likelihood of health risks due to exposure to dangerous substances; Results of the second open public consultation show a large consensus (75% of respondents) about the need for the minimum quality requirements to address the protection of human health of public directly exposed to reused water (e.g. workers; see Annex 2).
- **Employment**. 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 suggests that investments in wastewater reuse have a growth and employment multiplier of 3.5[63] providing a positive contribution for employment;

- **Governance and good administration**. 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. The Territorial Impact Assessment (Annex 9[64]) shows that setting minimum quality requirements could improve government effectiveness. Eastern European regions in Latvia, Lithuania, Poland, Romania and Bulgaria as well as Italian and Greek regions and some Spanish regions could gain a moderate to high positive impact on government effectiveness. Most of the other regions would gain a highly positive impact. 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). Compared to the baseline, this would be considered as a lost opportunity.
- **Public acceptance**. Adoption of the EU wide minimum quality requirements as well as aligning less stringent national requirements with the proposed EU wide standards would contribute to consumer protection by ensuring an 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. 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); therefore currently public acceptance is greater in countries where water reuse is already taking place, for instance in Spain.

The results of the second public consultation show a relative consensus among respondents about reused water in irrigation as being at least as safe as compared to water abstracted from rivers. This perception is more controversial regarding groundwater. There is a large consensus among respondents representing different economic sectors about the safety of reused water compared to water from rivers, as nearly 70% of them (in each sector but

[63] Appendix D of AMEC study, Processed data by the authors
[64] It is to be noted that the TIA has been concluded before the JRC modelling has been completed, hence there is a potential discrepancy regarding the available data.

agriculture, where this figure is closer to 60%) consider reused water as at least as safe. There is also a consensus between different types of stakeholders, as more than 60% of respondents from each group indicate that they perceive reused water as at least as safe as using water from rivers, with private companies having a particularly favourable opinion. The large majority of respondents from Southern EU Member States and others in high water stress also report a positive perception of the safety of reused water in agriculture compared to freshwater. On the other hand, the results of the consultation show a more negative perception from respondents of the safety of reused water compared to groundwater, as nearly 50% of respondents perceive it as not as safe. This is particularly true for respondents from Northern EU Member States and for respondents from the health sector, for which this figure raises to nearly 70%.

Figure 20: Summary of social impacts

2030 (50)	**Option Ir1** **Legal instrument** "one-size-fits-all" approach + RMF	**Option Ir2** **Legal instrument** "fit-for purpose" approach + RMF	**Option Ir3** **Guidance** "fit-for purpose" approach + RMF
Employment	Positive	Positive	Neutral
Public and occupational health	Positive	Positive	Neutral
Governance & good administration	Positive	Positive	Neutral
Public acceptance	Significantly positive	Positive	Neutral

6. Comparing the Options

This section compares the policy options to the baseline in terms of their effectiveness, efficiency and coherence, as well as their environmental, economic and social impacts (see overview in Figure 21 below). The comparison of the policy options is done in the context of their respective abilities to meet the general and specific objectives of the initiative, as set out in section 2.2 above.

Figure 21: Summary of environmental, economic and social impacts

Policy option / Category of Impacts, Effectiveness, Efficiency & Coherence	Agricultural irrigation		
	Ir1 Legal instrument "one-size-fits-all" approach + RMF	**Ir2 Legal instrument "fit-for- purpose" approach + RMF**	**Ir3 Guidance "fit-for purpose" approach + RMF**
Environmental	Slightly negative	Positive/Significantly positive	In the range of neutral to significantly positive depending on to what extent it is followed
Economic	In the range of slightly negative to neutral	Positive/Significantly positive	Positive, if Guidance is followed Neutral, if Guidance not followed
Social	Positive	Positive	Positive, if Guidance is followed Neutral, if Guidance not followed
Effectiveness	Negative	Positive	Positive, if Guidance is followed Neutral, if Guidance not followed
Efficiency	Negative	Positive	Positive, if Guidance is followed Neutral, if Guidance not followed
Coherence	Neutral/Negative	Positive	Positive, if Guidance is followed Neutral, if Guidance not followed

6.1. Effectiveness of the policy options

In sum, based on modelling results, the different policy options contribute to the objectives of reducing water stress and nutrient pollution in proportion to the additional amount of reused water available at the assumed acceptable costs of of 50 cents per cubic meter. Figure 22 below (also in above section 5.2.2.2 Adapting to climate change) provides a comparison with the baseline, where it is assumed that approximately 600,000 m3/year of additional water will be reused, i.e. from the current 1,100 million m3 to 1,700 million m3 (see Section 1.4.2). Therefore the baseline would not significantly reduce the water stress level, and alleviate water scarcity, so it would not significantly contribute to effectively achieving the objectives set. In comparison with the baseline scenario, option Ir1 would achieve even less water stress reduction than the baseline at a total cost below 50 cents per cubic meter, so would not be effective. Option Ir2 would be very effective as it would lead to a significantly higher uptake of water reuse at acceptable costs. Ir3 would be effective to the degree to which Member States would implement the Guidance.

Figure 22: cumulative volumes (m3/year) that can be allocated below or at a given cost in Europe, under « variable quality » and « higher quality » requirements. We refer to total (investment, operation and maintenance) costs. Source: Pistocchi et al., 2018.

	Below EUR 0.5/m3	**Below EUR 0.75/m3**	**Below EUR 1/m3**
Under Ir2	6,633,811,238.00	10,438,686,582.00	11,571,593,978.00
Under Ir1	827,229,354.00	8,747,570,594.00	11,028,173,972.00
Baseline	1,700,000,000.00		

Policy option Ir2 would be effective in relation to the specific objective as it sets a common methodology for defining requirement for reuse of treated wastewater used for agricultural irrigation. It would be effective as it addresses the underlying driver 2 (see chapter 1.3.2) on the uneven regulatory framework at Member States and the two sets of risks defined in Figure 5. Moreover, it would reduce the risk of potential trade barriers as there would be certainty on how the food products were irrigated and that this practise is safe both for consumers, the workers on the field and the environment. Therefore this policy option does address those drivers of the problem that the initiative intended to address, namely driver 2 and 3 (see chapters 1.3.2 and 1.3.3.).

Given the fact that under Ir1 the quality requirements are too stringent and therefore Ir1 would rather inhibit the uptake of water reuse than supporting it, it is not effective in achieving the overall objective, even if Ir1 would meet the specific objective of setting a common methodology as regards defining minimum quality requirements for reused water.

Option Ir3 would only be partially effective as those Member States who decided to apply the guidance would follow a common methodology for defining minimum quality requirement for water reuse, however overall the approach would continue to be fragmented.

As the overall objective on increasing the uptake of water reuse also depends on other factors, for instance the underlying driver 1 (on reused water being less attractive than conventional water resources) and 4 (on lack of consumer trust) shown in the problem definition, these factors can pose a limitation to achieving the overall objective and to reaching the uptake volumes shown in Figure 23. These factors are not addressed by this initiative and are outside of its scope, as already stated in the problem definition (see chapter 1.3.1 and.1.3.4). However, there are actions being undertaken (i.e. improving the implementation of the Water Framework Directive, organising information campaign to inform the public about water reuse) also on these external factors, but not in the remit of this impact assessment and initiative. Nonetheless, options Ir1, Ir2 and to some extent Ir3 would result in improved consumers' trust in relation to water reuse because there would be more certainty on the safety of water reuse practises due to common minimum quality requirements within Europe.

Moreover, effectiveness of the options also depends on the extent to which farmers would have an incentive to apply water reuse for irrigation purposes. Even if the above factors 1 and 4 pose a limitation to achieving the overall objective, they are not likely to significantly undermine the effectiveness of this initiative, because the analysis of impacts (see chapter 5.2.2.1) has shown that it is reasonable to assume willingness to pay for the availability of reclaimed water for agricultural irrigation at the assessed cost of 50 cents per cubic meter in water stressed areas. In other words farmers would be willing to pay the limited extra cost of reused water in order to save their crops from severe water shortages and droughts as in these cases the benefits would outweigh these limited extra costs.

Furthermore, the degree of effectiveness in reaching the general policy objective will vary depending on the policy option and water reuse practices currently adopted in different Member States in terms of the use of treated wastewater:

No new action – Baseline for treated waste water reuse for agricultural irrigation would not be effective in reaching the overall objective. As highlighted in Section 1.4.2, 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 option Ir3 (if followed) would vary across the Member States due to its 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. At the same time, introduction of EU wide Guidance 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. On the other hand, if a Member State with currently more stringent national reuse standards were to decide to align (lower) the national system with the proposed EU requirements, this might result in a lower level of treatment required, subsequently, lower costs of treatment, but at the same potential compromised public acceptance;

- A large number of Member States (22) do not currently have national standards on the reuse of treated waste water. Taking into consideration these two factors, this policy option is not expected to significantly increase uptake in treated waste water reuse or to contribute significantly to addressing the key barriers to waste water reuse discussed in Section 1.

The implementation of policy options Ir2 and Ir3 (if followed) 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. 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 proposed minimum quality requirements and risk assessment approach. 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 (see also Annex 6).

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 minimum requirements and a risk assessment approach, 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.

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 not be affected. The proposed EU minimum requirements and a risk assessment approach considered in this assessment for water reuse in agricultural irrigation 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.

6.2. Efficiency of the policy options

The degree of efficiency in reaching the general policy objective is assessed in terms of the respective costs involved. It will vary depending on the policy option and water reuse practices currently adopted in different Member States regarding the use of treated wastewater:

No new action – the Baseline for agricultural irrigation 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).

Figure 22 above clearly shows that option Ir2 provides more volume of treated waste water, hence more benefits, than option Ir1 at any given cost, and is therefore more efficient. The efficiency of option Ir3 depends on the extent to which Member States would follow the Guidance and is therefore considered less efficient than option Ir2.

Policy options Ir3 (if followed) – development and promotion of a non-binding Guidance would involve limited additional treatment, monitoring and administrative costs. In particular, Member States that have national requirements in place already are most likely to retain these, while Member States that do not have such national requirements 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.

The implementation of all policy options Ir1, Ir2 and Ir3 (if followed) 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 waste water reuse practices would not incur administrative costs of transposition, in case the proposed instrument is a Regulation. In case a Directive is proposed, additional administrative burden is expected due to the required transposition, in particular in those Member States who do not make use of water reuse and do not intend to engage in such a practice.
- Member States with existing national standards that are relatively more stringent than the minimum 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.

6.3. Coherence of the policy options

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

As options Ir2 and Ir3 (if followed) would reduce water stress levels, these 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). Option Ir1 would not be coherent under the assumed cost of 50 cents per cubic meter, because it would lead to higher water stress levels than the baseline, so it would undermine other policies like the EU climate change adaptation strategy.

In addition, options Ir1, Ir2 and Ir3 (if followed) 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 possible trade barriers, and would be fully coherent with the existing Regulation on the Hygiene of Food Stuff.

Further information on the coherence of the preferred option with the existing legislation is included in Annex 3.

6.4. Nature of the instrument

As set out in the above analysis, the purpose of the new instrument on water reuse for agricultural irrigation would be to facilitate the uptake of water reuse wherever it is appropriate and cost-efficient, thereby creating an enabling framework for those Member States who wish to practice water reuse. This impact assessment considers the full array of legal instruments, namely amending one of the existing Directives, a new Directive or Regulation, as well as the non-binding form of a Guidance

Most of the existing EU legislative framework on water is composed of Directives (e.g. WFD and its associated Directives, Drinking Water Directive, UWWTD, Bathing Water Directive, Marine Strategy Framework Directive). This choice of instrument not only reflects the need for EU legislation to accommodate pre-existing national institutional arrangements and legislation in Member States but, among other things, also the intrinsic nature of water management which has to adapt to highly varying situations in terms of natural characteristics of water resources and of the human activities impacting their status.

Also for water reuse practices there is a wide variation across the EU (see Annex 6) but there are much less pre-existing institutional arrangements at national level. When considering new legislation on water reuse, it should be noted that the legal instrument of a Directive would easily be able to accommodate the fact that Member States may wish to either keep existing national standards (in case they are more stringent than the EU minimum requirements) or introduce more stringent national standards if a Member State finds this more appropriate.

One possibility is to amend an existing legal framework where water reuse is already mentioned, in particular the UWWTD. However, an amended or new Directive would require transposition into national legislation by all Member States. While water reuse is certainly a promising option for many Member States, it needs to be considered that at present only 6 Member States (CY, EL, ES, FR, IT, PT) can build on specific coverage in their legislation or in national non-regulatory standards. The transposition obligation applies for all Member States, whether they intend to reuse water or not. This would result in the burden of introducing fully new legislation which may not be proportionate.

The possibility of allowing for an opt-out from a possible new Directive has been considered. Such opt-outs can only occur by way of negotiation after a Directive has been adopted by the co-legislators. The opt-out possibility is generally envisaged for more permanent situations[65]. In the case of water reuse, however, a more flexible possibility for phase-in is appropriate in case certain Member States decide to introduce the practice at a later stage; this possibility would be better provided by the legal form of a Regulation.

Moreover, an amended or new Directive would necessarily leave flexibility in transposition of the requirements. While this would accommodate for differences across the EU, this would pose a limitation in meeting the objectives set, in particular as regards the Internal Market and

[65] For example, Malta opted out of a Directive on the interoperability of the rail system within the European Union because it has no railway system and no plans to introduce one.

in setting a common level playing field. This limitation was already identified in the impact assessment of the Blueprint in which a Regulation was eventually the only regulatory policy option assessed in detail.

While the two open public consultations demonstrated a broad support by all categories of stakeholders for a binding approach (i.e. a Directive or Regulation), several comments from respondents in the second consultation expressed a preference for a Directive, either explicitly or implicitly in view of its binding character together with its flexibility allowing adaptation to local contexts and needs, but this could be achieved with other tools, notably the suggested introduction of the risk assessment approach (see Annex 2). It is true that flexibility is necessary in order to address adequately the risks to local public health and to the local environment. However, it is equally true that a rather uniform approach is needed for the relevant health risks for food products placed on the Internal Market. This should be the main consideration in choosing between amending an existing Directive or introducing a new Directive/Regulation or Guidance.

Requirements linked to the Internal Market are frequently introduced by way of a Regulation to ensure direct applicability to operators. While the main objective of the new initiative is environmental (contributing to alleviating water scarcity), as discussed above, the Internal Market dimension is a crucial link in the intervention logic of the initiative and must be addressed at the same time in order for the initiative to reach its main objective.

On the basis of the above analysis on the most appropriate legal form, both a Directive or a Regulation may be chosen, each with certain advantages and disadvantages.

6.5. Preferred option

On the basis of the above analysis in terms of the efficiency, effectiveness and coherence of the policy options for agricultural irrigation, both the "fit-for-purpose" approach and the baseline are expected to better address the objectives of the initiative than the "one-size-fits-all" approach; the "fit-for-purpose" approach can deliver significantly more benefits than the baseline. Considering all environmental, economic and social implications, a **legal instrument applying the "fit-for-purpose" approach (Ir 2) is the preferred option** rather than a Guidance document because it is able to provide the highest volume of treated waste water at an affordable cost level combined with additional economic and social benefits.

It would enable reusing more than 50% of the total water volume theoretically available for irrigation from wastewater treatment plants in the EU and avoid more than 5% of direct abstraction from water bodies and groundwater, resulting in a more than 5% reduction of water stress overall. This would be a considerable contribution to alleviating water stress in the EU and thereby correspond to the overall objective of the initiative.

The proposed EU legal instrument would have an enabling function and provide for a timely reaction to a growing EU-wide problem. Its implementation is expected to (1) raise awareness, (2) provide reassurance that experts have transparently analysed what is actually safe for all EU citizens and (3) ensure a level playing field and thereby provide an incentive for farmers, industry, citizens and others to explore the opportunities stemming from water reuse. This could include purchasing agricultural products that were currently not chosen by certain consumers; it could also mean further research, technology development and investments, as well as job creation.

For the choice of legal instrument, the possibilities of a Directive or a Regulation are both considered suitable, each with certain advantages and disadvantages. While a Regulation would cater better to the enabling nature of the initiative, a Directive may allow for easier flexibility in terms of setting more stringent national requirements (while at the same time imposing a transposition burden on all Member States, including those who do not wish to practice water reuse at the present moment).

7. MONITORING AND EVALUATION

Consistent with the objectives of this initiative, its monitoring will aim at evaluating policy effectiveness in the EU in terms of:

- the evolution of water scarcity,
- the development of water reuse for agricultural irrigation,
- compliance of water reuse practices with the minimum requirements, including the risk management approach.

A Fitness Check of EU environmental monitoring was carried out and presented by the Commission in June 2017; it includes an action plan to streamline environmental reporting to be implemented in the coming years[66]. Monitoring needs for the present initiative have been elaborated according to the principles highlighted in this Fitness Check, in particular:

- efficiency of reporting with a moderate, justified and proportionate administrative burden, by avoiding overlaps and streamlining with existing reporting obligations, both in terms of content, timing and frequency;
- relevance in content, by focusing on information that is strategic, quantitative and regulation-driven, and limiting the amount of textual information
- EU added value, by making available comparable and consistent data available at national level complemented with active dissemination of relevant information at national level.

Existing reporting obligations for Member States under the WFD (Article 15) and the UWWTD (Articles 15, 16 and 17) already include the necessary information on indicators relevant to measure the success of this initiative, In particular, under the WFD, Member States are to report every six years for each of their river basins[67]:

- quantitative status of groundwater bodies;
- surface water and groundwater bodies subject to a significant pressure from abstractions, and the main responsible sector(s);

and, in case water abstraction has been identified as a significant pressure in the basin:

  - o Water Exploitation Index (WEI+)
  - o annual volume of water used by sector (consumptive uses)
  - o annual volume of reused water;

- whether water reuse has been included in the river basin management plan as a measure in terms of managing water resources.

Under the UWWTD, Member States are to report every two years, inter alia, for each of their agglomerations (and associated urban waste water treatment plant) whether at least part of the effluent is reused and for which purpose.

Information reported by Member States to the Commission is the basis for the elaboration of periodic Implementation reports by the Commission to the European Parliament and the Council. Recent steps have been taken to improve the quality of reporting on existing

[66] Report "Actions to Streamline Environmental Reporting" (COM(2017)312) and Fitness Check evaluation (SWD(2017)230)

[67] WFD reporting guidance 2016

provisions to water reuse and more accurate information is expected to be available as of the next implementation reports under the two Directives in 2018. Taking into account these on-going improvements, existing reporting streams under the WFD and UWWTD will mostly be sufficient to inform progress as regards the evolution of water scarcity and development of water reuse for agricultural irrigation in the EU and only limited additional monitoring and reporting requirement will be developed to this regards.

The monitoring requirements will primarily be imposed to the operators of the reclamation plants and the Member States shall ensure that the information is made available online to the public. The proposed Regulation would include additional monitoring requirements on the quality of reclaimed water. Member States would need to verify compliance with the permit conditions based on monitoring data obtained pursuant to the legal instrument on water reuse, the Water Framework Directive and the Urban Waste Water Treatment Directive and other relevant information.

Detailed reporting obligations will be developed with consultation of experts in Member States taking into account experience gained in the Fitness Check on environmental reporting and follow-up actions, in particular as regards the use of advanced information and communication technologies (ICT).

Given the expected evolution both in knowledge and in the policy framework as regards contaminants of emerging concern the legal instrument shall include a review clause within 6 years after its entry into force.

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SWD(2018) 249 final/2

PART 2/3

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

Proposal for a Regulation of the European Parliament and of the Council on minimum requirements for water reuse

{COM(2018) 337 final} - {SEC(2018) 249 final} - {SWD(2018) 250 final}

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ANNEXES

Annex 1 – Procedural information

Lead DG: **DG ENV**	Agenda planning/WP reference: 2017/ENV/006

Organisation and timing

Work on this impact assessment started in August 2013, when DG ENV signed a contract with an external contractor to further analyse the possibilities for the maximisation of water reuse in the EU, and to assess the impact of the possible measures.

Taking over a pre-existing Inter-Service Group an Impact Assessment Steering Group (IASG) led by DG ENV was set up and met 9 times, between December 2014 and September 2017. The Directorates-General (DGs) of the Commission SG, SJ, AGRI, CLIMA, CNECT, ECFIN, GROW, JRC, MARE, MOVE, REGIO, RTD, SANTE, and TRADE were invited to participate in the work of this group; all nominated representatives. AGRI, SANTE, JRC, RTD and SG were the DGs that contributed the most actively to the work of the IASG. All nominated members of the group were regularly consulted and informed on progress.

Consultation of the Regulatory Scrutiny Board (RSB)

[NB: section to be replaced in the final draft after RSB "formal" consultation, to briefly explain how the Board's recommendations have led to changes compared to the earlier draft. This will include a table with the first column identifying the Board's recommendation and the second column how the IA Report has been modified in response).]

A meeting between all members of the RSB and DG ENV was held on 13 February 2017, also attended by members of SG and JRC, aiming at providing early feedback on the main expectations of the Board regarding this initiative. The table below summarises the comments raised by the RSB in the meeting and how they were followed-up:

Preliminary points raised by the RSB on 13 February 17	**Follow-up in the present draft IA report**
The upcoming IA will need a clearly presented and thorough problem definition. It would be important to identify the main issues, where problems occur, the sectors and the member states it mostly affects, the magnitude of the problem, and how it would develop in the absence of additional action. It should demonstrate that this is a problem present at the EU level, potentially examining the problems at the level of member states. This in turn could be efficiently used to demonstrate the need to act at the EU level, and should feed into the discussion on subsidiarity and proportionality. A good problem definition would also enable DG ENV to better identify potential benefits.	The problem definition elaborates on the issues affecting the different Member States and sectors. Scope and magnitude of the two main objectives (reuse of treated wastewater for irrigation purposes and for maintaining groundwater supply) has been clarified. It is explained why this scope has been chosen and other areas for water reuse, e.g. industrial use have not been considered. Particular attention was paid to subsidiarity and proportionality issues. Different sets of options were developed for these two areas also to take account of proportionality.

The IA should clarify the scope of the initiative and the (possibly different) magnitude of each of the two main objectives: reuse of treated wastewater for irrigation purposes and for maintaining groundwater supply.	
Potential obstacles and bottlenecks should be well presented and backed up by evidence (e.g. the problems for the functioning of the Internal Market described in the inception IA).	There was one case where direct evidence exists on this matter. Otherwise the initiative tackles the perceived health risk and environmental risks associated with a fragmented framework at EU level.
DG ENV mentioned that they believe there is only a limited possibility for quantification, especially concerning the uptake of water reuse. The RSB pointed out that DG ENV could examine other possibilities of providing a convincing justification. This could include evidence from well-designed and well-presented consultations.	In addition to results from modelling evidence from extensive stakeholder consultation has been sought and included in the present report. In order to maintain the robustness of modelling, the amounts of water that become available under the different options has been quantified in order to reduce water stress, but the value of this water has not been monetised as no coherent and conclusive evidence exists on this matter. The report summarises several studies in this field and their diverging conclusions on the value of water in terms of reduced water stress.
The IA should also analyse the possibilities and challenges presented by the quick evolution of technology. If the uptake of water reuse is not known, the IA could look at different scenarios (high/low) explaining the assumptions made. The IA should also explain conditions that would make this initiative useful and proportionate to the costs generated.	The hydro-economic modelling by the JRC has followed this approach. Moreover an assessment of territorial impacts has been carried out, so as to triangulate the information as far as possible and to arrive at more solid conclusions.
Shaping the public perception (or misperception) seems to be an important issue. DG ENV should therefore also pay attention to communication related to reused water and consider non-legislative actions. Health-related problems do not currently seem to be addressed in the main objectives, but seem to be implicitly in the problem definition. This dimension should be included in the IA.	The problem definition identifies explicitly a perceived health risk and environmental risks which are resulting from the uneven framework existing in the EU to regulate water reuse. EU action on common quality requirements is expected to positively contribute to public perception on water reuse and to tackle both risks above.
If the initiative intends to differentiate in the	The initiative aims at setting minimum

application of standards between Member States, the reasons should be well substantiated.	quality requirements, so in case a Member State intends to allow this practice, it needs to comply with these as a minimum, but is free to develop more stringent requirements. The approach does not differentiate between Member States in relation to possible cross-border health and environmental impacts. It leaves flexibility to Member States to manage risks associated with reuse on the local public and environment. Reasons for this are linked to the local nature and extent of these risks and application of the subsidiarity principle; they are substantiated in the report.
The "fear" and "uncertainty" dimensions seem to be important for this initiative. The IA should address the question of how to generate more confidence. This does not necessarily require legislation. If results from consultations indicate that there is a strong demand for higher standards, this could provide the basis of a strong argument to accept the higher costs associated with them.	As part of the Circular Economy Action Plan beyond this initiative the Commission already committed to provide support to further knowledge and technological development in order to reduce uncertainty related to water reuse practices. Consultation activities have confirmed the demand for legislation to secure EU-internal trade of agricultural products irrigated with treated waste water. The scientific work underlying the proposed minimum quality requirements including the check by EFSA and SCHEER ensure that these requirements are sound and safe. So the pure existence of such requirements contributes already to reducing uncertainty and fear as consumers can be sure about the safety of European irrigated food products and aquifer recharge practises. Impacts on irrigation water cost have been addressed in the report.

The RSB discussed the Impact Assessment report on 25 October 2017. A negative opinion, requesting a resubmission of the Impact Assessment report, was issued on 27 October 2017. The table below summarises the main and further considerations and adjustment requirements raised by the RSB in its opinion and how they were followed-up:

Main points raised by the RSB in its opinion of 27 October 2017	**Follow-up in the revised draft IA report**
(B) Main considerations	
(1) The report identifies water scarcity as the main issue but does not clearly document this problem's size, geographical scope or likely	Relevant projections on water scarcity and climate change scenarios were introduced in Section 1.1. Further information

evolution. It does not explain whether this is an immediate problem or an issue for the future as a result of climate change.	underpinning the projections is available in Annex 4.
(2) The justification for intervention at the EU level is weak. The report does not substantiate lack of consumers' trust in the safety of agricultural products sold between Member States. Neither does it demonstrate the need for EU standards on reused water to alleviate water scarcity, to preserve the internal market for agricultural products, to protect consumers' health or to promote innovation in the circular economy.	The over-arching objective of the EU initiative on water reuse is to increase an uptake of water reuse as a measure contributing to the alleviation of water scarcity in the EU while maintaining the safety of health and addressing environmental risks associated with water reuse practices. The problem definition has been revised accordingly. The potential contribution of an EU legal instrument on water reuse towards reducing water scarcity is presented in Section 5 and further data is available in Annex 4. The Internal market dimension is now better presented in Section 1.3.3.
(3) The report lacks a clear analysis of the different situations across Member States with regard to quality requirements for reused water, and how the initiative would affect these respectively. The report does not adequately describe Member States' and consumer groups' views on this.	The IA report, as well as the JRC technical report is based on thorough analysis and consultation of Member States. Comparison of current standards on water reuse in selected Member States versus the JRC proposal on water reuse has now been included in Annex 6. The Member States views have been updated with recent information of the last CIS ATG on Water Reuse that took place on 6-7 November 2017. Consumer groups' views are covered by the results of the open public consultations, which are presented in Annex 2.
(4) The report does not adequately show how the initiative would be effective. It lacks a clear analysis of links to price setting and clean water prices.	The initiative has been put in the context of water pricing policy; information that was presented in Annex 5a in the previous version has been introduced in the main text. The main reference is Art. 9 of the WFD and its implementation and enforcement. Relevant information is presented in Section 1, and in particular Section 1.3.1 Factor 1. However, it has to be noted that water pricing as such is not going to be addressed by the initiative on water reuse, as there are other means already in place. The effectiveness of the initiative has now been further elaborated, i.e. information that was presented in Annexes in the previous version has been moved to Section 6.
(C) Further considerations and adjustment requirements	
(1) Clarify problem and need for intervention. The report should define from the outset the water reuse that falls within the	The language in the scope definition has been improved. Aquifer recharge has been discarded based on the subsidiarity

scope of the proposal. In particular, it should explain why the initiative deals only with irrigation and aquifer recharge. It should present projections of water scarcity across the EU, and explain why the problem needs to be addressed at the EU level. The report should make clear to what extent existing regulatory standards concerning agricultural product safety fail to create consumer trust needed for a free flow of agricultural goods, and how EU minimum standards for reused water would solve this problem.	assessment (see Annex 11), consequently, no detailed impact assessment is included. Relevant projections on water scarcity and climate change scenarios were introduced in Section 1.1. Further information underpinning the projections is available in Annex 4. The interplay between existing standards and potential new EU minimum standards especially for agricultural irrigation and their expected impact has been set out in more detail.
(2) Clarify the choice of objectives. The report should present clear links between the objectives and the main problems. It should explain whether addressing water scarcity is the higher level objective, to which targets for water reuse in agriculture and for aquifer recharge contribute. It should detail how achieving these objectives might conflict with the free flow of agricultural goods. The report should clarify the interlinkage and trade-offs between trade, environmental and public health objectives.	The intervention logic has been clarified. The different levels of objectives have been made more explicit and linked directly to the problem definition.
(3) Stakeholder views should be more fully presented. Evidence of Member State support for standardisation should be provided and argued against stakeholder resistance and the current different national levels of requirements for quality of reused water. In the context of stakeholder support, it would be helpful to show more evidence of consumer perception of a problem and how minimum standards would contribute to greater trust.	Stakeholders' views based on the open public consultation are presented in the revised report, making a reference to Annex 2 when relevant.
(4) Subsidiarity issues. Given big climate differences across the EU, the justification for EU intervention should explain whether minimum standards would be helpful for all or if they might disadvantage some Member States. The report should clarify whether the legal base to act is an environmental objective or a single market base. It should explain why the regulation of a risk assessment framework for aquifer recharge is not discarded up front, as the report already on page 25 states that aquifer recharge does not directly entail any issue linked with the placement of products on the internal market.	The intention of this initiative is to introduce an enabling framework for water reuse practices for those Member States who wish to implement them. Those who are not affected by water scarcity exacerbated by climate change will not be obliged to pursue any water reuse practice. Given the environmental legal basis, explicitly stated in Section 2.1, those Member States would be able to maintain/apply more stringent requirements. Aquifer recharge is now discarded upfront based on the subsidiarity assessment (more information in Annex 11).
(5) Choice of the legal instrument. The	The nature of the instrument is now placed in

report should explain why minimum standards would be best enforced by a Regulation rather than a Directive, especially when the case of subsidiarity is not clear and the proposal covers minimum standards with possibility for derogation. The report should explain why "relevant health risks for food products placed on the Internal Market" (p. 20) justify the choice of a Regulation, although other water related EU acts, including drinking water, are Directives. Stakeholders also broadly appear to favour a Directive. The report should make clear that Member States with more restrictive limits will have to justify derogations from minimum standards. It should consider the implications of lowering existing standards in such cases	Section 6, in which arguments both in favour or against a Directive or Regulation are listed. The conclusions of the Blueprint were the departure point for this impact assessment, hence a Regulation has been identified as preferred option. However, following further consideration, the possibility of a Directive is analysed as well in more detail.
(6) The preferred option Regulation *"fit-for-purpose"* and the development of standards in collaboration with Member States. The preferred option, with a collaborative setup with Member States, should be more clearly explained. The report needs to explain how minimum standards would result in greater reuse of water for irrigation. The report should discuss what motivates farmers to substitute reused water for fresh water for irrigation. It should point out that the willingness to pay for reused water will differ across regions, depending on differences in freshwater pricing. It should indicate that costs for the supply of reused water may be greater than the assumed willingness to pay of 0.5 €/m3. The report should explain that this qualifies the calculation of uptake and consequent benefits.	Section 5 has been revised to better reflect the willingness to pay based on the modelling data included in Annex 4.
(7) The lack of trust issues in the safety of agricultural products sold between Member States The report needs to spell out how standards will protect public health and the extent of scientific evidence supporting them. The report should provide evidence that reuse of water for irrigation leads to marketing problems for agricultural goods. It should critically discuss how minimum standards for reused water have to complement agricultural product safety standards. The impact assessment should	This has now been clarified in the problem definition, Section 1.3.

critically discuss whether minimum standards, with the possibility of more stringent national or regional standards, overcome the problem of consumers discriminating between products from different regions.	

The RSB received a revised version of the draft Impact Assessment report on 1 December 2017. A positive opinion with reservations was issued on 19 January 2018. The table below summarises the main and further considerations and adjustment requirements raised by the RSB in its opinion and how they were followed-up:

Main points raised by the RSB in its opinion of 19 January 2018	**Follow-up in the revised draft IA report**
(B) Main considerations	
The context section of the report does not sufficiently reflect the shift in emphasis from water management to environmental standards for trade in agricultural goods. Information about parallel EU initiatives and alternatives in this area has not been sufficiently detailed in the problem definition of this initiative.	The context section 1.1. (pg. 4) was modified accordingly to ensure coherence with the main objective of this initiative, i.e. addressing water scarcity through an increased uptake of water reuse wherever it is relevant and cost-efficient, as well as contributing to the better functioning of the internal market through creating an enabling framework for water reuse. The problem definition section was modified accordingly (pg. 8).
(C) Further considerations and adjustment requirements	
(1) The problem definition and the scope consider reuse of waste water in the context of an integrated approach to water management. The report could provide additional information on the potential of reused water and the alternatives. It could comment further on the proportionality of this proposal in light of other initiatives. This might strengthen the case for the scope of the initiative and in particular for the creation of an enabling framework for increased uptake of water reuse, in particular for agricultural irrigation. The report does not refer to the Fitness Check of EU environmental monitoring until very late in the report. The report could use an early reference to all relevant information for a good understanding of the EU context and scope of the initiative.	The information included on alternatives to water reuse has been expanded to make clearer what alternatives could exist and how they would compare to water reuse. Reference to the Fitness Check of EU environmental monitoring introduced in Section 1.1.
(2) The report states that Member States' inaction to address the problem of environmental risks of water reuse results in a Single Market issue. The report could	Section 4.2 modified accordingly to reflect the contribution of the proposed action to the functioning of the Single Market.

strengthen this argument by highlighting how the options include the Single Market dimension and how the Single Market will function despite diverging quality requirement limits in Member States.	
(3) The report now makes a more robust case for the EU to act. It explains the level of support among most Member States. The subsidiarity analysis added in Annex 11 justifies discarding the measure about aquifer recharge, while also documenting substantial stakeholder interest in the issue. To clarify the EU intervention, the report could include further specific reference to the most EU-relevant problem drivers in section 2.1.	Section 2.1 slightly modified.
(4) The report has appropriately adjusted the objectives to the changed scope. If there is a corresponding shift in operational objectives, the report might explain what the implications would be for future monitoring and evaluation. This would include changes to the intervention logic, indicators for monitoring and benchmarks that those indicators would be monitored against.	
(5) The report could be made more reader-friendly by incorporating the problem tree into the main text, conventionally labelling, numbering and footnoting tables and figures, and more sparing use of bolding, underlining and italics.	The problem tree was incorporated in the main report (pg. 11, Section 1.3). The formatting was improved.
The Board takes note of the quantification of the various costs and benefits associated to the preferred options of this initiative, as assessed in the report considered by the Board and summarised in the attached quantification tables. *Some more technical comments have been transmitted directly to the author DG.*	Following the revision of the JRC modelling, the quantification of the various costs and benefits associated to the preferred options of this initiative has been revised accordingly.
(D) RSB scrutiny process	
The attached quantification tables may need to be adjusted to reflect changes in the choice or the design of the preferred option in the final version of the report.	Following the revision of the JRC modelling, the quantification of the various costs and benefits associated to the preferred options of this initiative has been revised accordingly.

Sources used in the impact assessment

The main information sources for this Impact Assessment are the preceding impact assessment (2012) and subsequent supporting studies as well as the scientific basis developed by JRC (minimum quality requirements), together with a hydro-modelling by JRC. Moreover, by teaming up with other Directorate-Generals (DG REGIO and DG RTD) specific aspects have been assessed, namely the impacts on innovation and territorial impacts.

Quality of the information collected: Significant effort was put into the collection of evidence and where possible, triangulation was performed to cross check the validity and robustness of information. Nevertheless, it was not feasible to arrive at monetised and quantified impacts on all aspects. In these cases, a qualitative assessment was performed. The Impact Assessment builds on detailed data on water scarcity and droughts in Europe, as well as future projections and a cost-benefit analysis of the use of treated waste water for agricultural irrigation. The modelling assumptions were based on expert judgements. The choice of options and the underlying scientific work developing minimum quality requirements was discussed with Member States and stakeholders in the context of the Common Implementation Strategy under the Water Framework Directive, and adapted accordingly.

Usefulness of the information collected. The underlying scientific work of developing the minimum quality requirements, the data collected and the modelling for the Impact Assessment are a useful basis for further decision-making.

COM(2012) 672, Report on the Review of the European Water Scarcity and Droughts Policy

COM(2012) 673, Impact Assessment for the Blueprint

BIO-Deloitte (2014), Optimising water reuse in the EU

COM/2015/614, Communication on Closing the loop - An EU action plan for the Circular Economy, Annex I

SWD (2015) 50, Report on the progress in implementation of the Water Framework Directive Programmes of Measures: The Water Framework Directive and the Floods Directive: Actions towards the 'good status' of EU water and to reduce flood risks

SWD(2017) 153, Commission SWD on Agriculture and Sustainable Water Management in the EU

Forzieri, G., Feyen, L., Rojas, R., Flörke, M., Wimmer, F., Bianchi, A.
Ensemble projections of future streamflow droughts in Europe (2014) Hydrology and Earth System Sciences, 18 (1), pp. 85-108. DOI: 10.5194/hess-18-85-2014

JRC (2014) Water Reuse in Europe: Relevant guidelines, needs for and barriers to innovation

Forzieri, G., Feyen, L., Russo, S., Vousdoukas, M., Alfieri, L., Outten, S., Migliavacca, M., Bianchi, A., Rojas, R., Cid, A. Multi-hazard assessment in Europe under climate change (2016) Climatic Change, 137 (1-2), pp. 105-119. DOI: 10.1007/s10584-016-1661-x

Amec Foster Wheeler Environment & Infrastructure (2016) UK Ltd, IEEP, ACTeon, IMDEA and NTUA, EU-level instruments on water reuse

CIS Guidelines on Integrating Water Reuse into Water Planning and Management in the context of the Water Framework Directive (2016) http://ec.europa.eu/environment/water/pdf/Guidelines_on_water_reuse.pdf

COM (2016)105, 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

Alberto Pistocchi, Alberto Aloe, Chiara Dorati, Laura Alcalde Sanz, Bernard Bisselink, Fayçal Bouraoui, Bernd Gawlik, Emiliano Gelati, Bruna Grizzetti, Marco Pastori, Ine Vandecasteele, Olga Vigiak, Hydro-economic analysis of the water reuse potential for agricultural irrigation in the EU. JRC Science for Policy Reports, 2017 (*draft*).

REGIO (2017) Assessment of territorial impacts

RTD (2017) Assessment of impacts on research and innovation

JRC (2017) Development of minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge

SCHEER (2017) Scientific advice on proposed EU minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge https://ec.europa.eu/health/sites/health/files/scientific_committees/scheer/docs/scheer_o_010.pdf

EFSA (2017) Technical report on proposed EU minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge http://onlinelibrary.wiley.com/doi/10.2903/sp.efsa.2017.EN-1247/epdf.

Report on Water reuse and recycling within EU reference documents https://circabc.europa.eu/sd/a/c2f004b6-4c4b-4bbc-8d7d-37938c6c6390/Water%20reuse%20%26%20recycling%20within%20EU%20Reference%20Documents.pdf

Characterization of unplanned water reuse in the EU (Final Report 2017), Jörg E. Drewes, Uwe Hübner, Veronika Zhiteneva, Sema Karakurt , TUM http://ec.europa.eu/environment/water/pdf/Report-UnplannedReuse_TUM_FINAL_Oct-2017.pdf

Report by FP7 project DEMOWARE: http://demoware.eu/en/results/deliverables/deliverable-d5-2-trust-in-reuse.pdf

WHO Guidelines for the safe use of wastewater, excreta and greywater http://www.who.int/water_sanitation_health/wastewater/wwuvol2intro.pdf

CDPH (2014) Regulations related to recycled water. California Code of Regulations. California Department of Public Health, Sacramento, California, USA.

EEA (2012) Towards efficient use of water resources in Europe. EEA report No 1/2012. European Environment Agency, Copenhagen, Denmark.

Annex 1a – Water reuse in impact assessment of Blueprint (excerpt)

The Commission has been considering the issue of water reuse for a number of years and has documented its findings to date in several steps. In the 2012 Communication "A Blueprint to Safeguard Europe's Water Resources" (COM(2012) 673) water reuse for irrigation or industrial purposes was found to have a lower environmental impact and potentially lower costs than other alternative water supplies, whereas it is only used to a limited extent in the EU. A Fitness check of EU Freshwater policy (SWD(2012) 393) published in November 2012, as a building block of the Blueprint, assessed the performance of the measures taken, both in environment and in other policy areas, in achieving the objectives already agreed in the context of water policy. It also identified the major gaps to be closed in order to deliver environmental objectives more efficiently. In relation to wastewater reuse, the Fitness check concluded that "alternative water supply options with low environmental impact need to be further relied upon" in order to address water scarcity. A particular issue emphasised by stakeholders in the public consultation of the Fitness Check was the lack of EU common quality requirements for reuse of wastewater in irrigation. Several policy options to promote water reuse were considered in the impact assessment of the Blueprint (SWD(2012) 382)

The following are more detailed excerpts from the relevant sections of the above mentioned documents, including the major gaps identified, whose closure can be partly addressed with increased water reuse:

Fitness Check of EU Freshwater Policy – SWD/2012/393[1]

2.3. Gaps - Managing water demand and availability

Moreover, alternative water supply options with low environmental impact such as water re-use need to be further relied upon. In this context, a particular issue that was emphasised by industry stakeholders in the public consultation was the lack of EU standards for re-use of waste water in irrigation. The concern expressed is that the lack of EU-level standards could inhibit free movement of agricultural produce in the single market and inhibit investment by the water industry.

2.5. Appropriateness of Policy instruments

The slow progress in relation to water efficiency in buildings and agriculture or on alternative water supply sources such as water re-use also raises questions about the relevance of continued reliance on voluntary approaches.

5.2. Coherence within EU water policy

It should be noted that the issue of re-use of waste water for different purposes (such as irrigation or industrial uses) is not specifically addressed by EU water policy through EU wide re-use standards (public consultation and stakeholder workshop). Although relevant to the Urban Waste Water Treatment Directive, this is not an issue of coherence between water legislation, but rather a gap in the policy framework (see section on relevance).

[1] http://ec.europa.eu/environment/water/blueprint/pdf/SWD-2012-393.pdf

A Blueprint to Safeguard Europe's Water Resources - COM(2012) 673

2.4. The vulnerability of EU waters: problems and solutions

In the stakeholder consultations leading to the Blueprint, one alternative supply option – water re-use for irrigation or industrial purposes – has emerged as an issue requiring EU attention. Re-use of water (e.g. from waste water treatment or industrial installations) is considered to have a lower environmental impact than other alternative water supplies (e.g. water transfers or desalinisation), but it is only used to a limited extent in the EU. This appears to be due to the lack of common EU environmental/health standards for re-used water and the potential obstacles to the free movement of agricultural products irrigated with re-used water. The Commission will look into the most suitable EU-level instrument to encourage water re-use, including a regulation establishing common standards. In 2015, it will make a proposal, subject to an appropriate impact assessment, to ensure the maintenance of a high level of public health and environmental protection in the EU.

Table 4

Blueprint's proposed action	Who will take it?	By when?
Propose (regulatory) instrument on standards for water re-use.	Commission	2015

3. CONCLUSIONS AND OUTLOOK FOR EU WATER POLICY

The Commission will consider developing a regulatory instrument setting EU-wide standards for water re-use, thereby removing obstacles to the widespread use of this alternative water supply. This would help alleviate water scarcity and reduce vulnerability.

Impact Assessment (IA) of the Blueprint - Executive summary (SWD/2012/381)[2]

1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

[…] Overall, stakeholders were supportive of non-legislative EU action to tackle water problems. […] Some legislative options were also supported, such as a possible new regulation on water re-use standards. […]

2. POLICY CONTEXT, PROBLEM DEFINITION AND SUBSIDIARITY

Second, there is a risk that the WFD goals will not be achieved because of a lack of integration and coherence with other policy areas […], further support is needed:

[…](7) for the uptake of water re-use through common EU standards.

[2] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52012SC0381R(01)

5. IDENTIFYING THE PREFERRED OPTIONS PACKAGE AND ITS IMPACTS

The assessment of the options can be considered as a screening of the various approaches for each of the 12 issues identified. On the basis of the assessment performed, it appears that in most of the cases, the most appropriate options fall under a guidance approach. The regulatory approach is recommended for only 3 issues (water efficiency in appliances/water related products, water re-use and knowledge dissemination) as the current policy context, in particular with respect to the implementation of the WFD and the MFF, leads to postponing most of the regulatory and conditionality policy options to a later stage. The preferred options are those in red and underlined in table 1.

Table 1: List of options considered in the Impact Assessment - options in red and underlined are retained

	Approaches			
specific objective	a) Voluntary	b) Regulation	c) Conditionality	d) Priority in funding
7 Water reuse	CIS Guidance CEN standard	Regulation	n/a	Under CSF & EIBloans

Impact Assessment (IA) of the Blueprint - SWD/2012/382[3]

- **Impact Assessment report (Part I)**

2.4 Problem definition for the Blueprint (pg. 18)
2.4.2. Lack of policy integration in support to specific measures

Even if a proper implementation of economic and communication instruments can help for a further uptake of measures that can provide a cost-efficient response to water resource problems, there are cases for which additional support from policy and funding instruments is needed:

…

- The lack of common EU **standards for water re-use** for agriculture and industrial uses limits a potentially important alternative water source - especially for water stressed areas where this option could be cheaper than desalinisation or transfers19. The lack of common health/environmental standards threatens farmers using re-used water to irrigate crops for export within the single market and prevents industry from making long-term investment decisions. It also constitutes a barrier for innovation.

2.7 The need to act at EU level (pg. 29, 31)
Lack of integration of water issues into other policies (pg. 31)

[3] http://eur-lex.europa.eu/legal-content/fr/TXT/?uri=CELEX:52012SC0382

- The main barrier to expansion of **water re-use** is the lack of common standards at EU level, in particular in agriculture. While guidelines for agricultural water re-use have been defined by the World Health Organisation36, and by different countries, such as the USA37 and Australia, a uniform solution for Europe is lacking. Establishing standards for the functional operation of the single market is an appropriate EU level response, taking into account EU Health, Agriculture and Energy policies.

4. Policy options (pg. 36)

4.7 Water re-use (pg. 39)

The problem analysis highlighted that a critical problem to address in the Blueprint is that there are no common standards for waste water reuse. Taking account of the detailed problem analysis and baseline, the following options were identified to be assessed within the Impact Assessment:

- develop CIS guidance on certification schemes for water re-use (Option 7a1),
- the Comité Européen de Normalisation (CEN) to adopt standards water re-use (Option 7a2),
- an EU Regulation establishing standards for water re-use (option 7b), and
- provision of funding through Cohesion Funds and/or EIB loans (Option 7d).

5. Analysis of the impacts of the options (pg. 41)

5.7 Water re-use (pg. 44)

The options concerned with water re-use all seek to stimulate the re-use of waste water in agriculture as a means of providing an alternative water supply and so reduce the pressure on surface and ground water sources and provide a stable supply to users in times of scarcity and drought. The impacts of water re-use are, therefore, common to all of the options and largely only differ to the extent that the options would be effective at stimulating water re-use.

The primary economic benefits of water re-use are to the agriculture sector and water industry sector. Water re-use ensures to farmers and horticulturalists a more reliable water supply, less dependant on precipitations, as it benefits from the priority given to drinking water in periods of drought, leading to more certainty in economic investment. Furthermore, farmers can benefit from nutrients contained in waste water, so reducing their costs for the use of fertilisers. The water industry sector benefits from alternative water treatment requirements, which can be less stringent and, therefore, less costly than requirements for treatment for discharge to surface waters.

The economic benefits translate into social benefits. Security of the agricultural producers enables jobs to be secured, providing benefits to local communities. Furthermore, it can enable traditional agricultural production to continue in water stressed areas that would otherwise be under threat from water scarcity and so maintain cultural traditions. However, health concerns do arise from the re-use of water for agricultural products. Therefore, the standards proposed to be adopted for options 7a, 7b1 and 7b2 would all be required to meet the necessary health standards. Furthermore, funding (option 7d) should only be provided to schemes which guarantee health standards are to be complied with.

The environmental benefits are proportional to the reduction in pressure on surface and ground waters from supply of re-used water as an alternative to abstraction. Ecological flows are more likely to be maintained, protecting aquatic ecosystems and, therefore, helping to meet WFD requirements. Furthermore, diversion of waste water to agriculture may result in less discharge of nutrients, etc., to surface waters.

The extent of these impacts is proportional to the effectiveness of the options. The primary problem facing water re-use is the lack of EU-level standards which could result in different standards across the Member States, leading to barriers in the trade of agricultural products. Voluntary standards (option 7a1) developed at EU level would provide a basis for a common approach, but the option cannot prevent Member States adopting a different approach and, therefore, cannot prevent barriers in the internal market. CEN standards (option 7a2) might be more likely to be adopted by Member States, but they suffer the same flaw as option 7a1. A Regulation (option 7b) does not have this problem and would guarantee that internal market barriers would not arise. The development of each of these options has similar costs, although the direct applicability of a Regulation would have lower burdens on Member States as it would not require transposition. The public consultation and stakeholder views all show more support for a binding Regulation as the effective means to overcome the problem compared to the other options. The option would be fully coherent with other EU water law and policy.

Option 7d (funding) is not an alternative to the other options, but can accompany any of the other options. Given public and private expenditure constraints, investment in water treatment and distribution for irrigation is constrained in some regions. Areas eligible for Cohesion Funds and EIB loans can benefit from additional investment support. The effectiveness of this option (and the resulting economic, social and environmental impacts) would be directly proportional to the level of available investment.

6. Identifying the preferred options package and its impacts (pg. 48)

6.1 Proposed package (pg. 49)

- Regarding **water re-use** there is a need to ensure the effective operation of the internal market to support investment and use of re-used water. The assessment, including stakeholder consultation, found that this can only be achieved through the development of new regulatory standards at EU level. Therefore, the preferred option is for the Commission to pursue appropriate health/environment protection standards for re-use of water and, subsequently, to propose a new Regulation containing these subject to a specific impact assessment.

- **Annex to the Impact Assessment report (Part II)**

2.2. Measures improving water availability (pg. 35)

2.2.1. Description

Desalination is the specialised treatment method used to remove dissolved minerals and mineral salts (demineralisation) from the feed-water (fresh water, brackish water, saline water, but mainly from sea water) and thus to convert it to fresh water mainly for domestic, irrigation or industrial use. In Europe, several countries have turned to desalination technologies, especially in the southern more water scarce areas. Several Member States use desalination as an **alternative water supply** source to remedy water stress situations. In 2008 Spain had the largest desalination capacity in the EU with up to 713 Mm3/day. Malta had a desalination capacity of 14 Mm3/day (more than 45% of its total water needs), while Italy reached around 0,75 Mm3/day, and Cyprus around 0,093 Mm3/day (TYPSA 2012). More and more Northern European Countries also use this option. For example, in the UK, the company Thames Water has built a desalination plant for meeting the future water demands of the London metropolitan area.

Water transfers – are used to transfer water from one river basin where water is considered abundant to another one where water is scarce. The interbasin transfer of water, when implemented on a large scale, is one of the most significant human interventions in natural environmental processes. Water transfer has potential for substantial beneficial effects through alleviation of water shortages that impede continuing development of regions without adequate local water supplies. But transfer also has potential to limit future development of the area of the transfer's origin and to produce other negative effects.

Groundwater recharge is a hydrologic process where water moves downward from the soil surface towards groundwater. Recharge occurs both naturally (through the water cycle) and man-induced (i.e. artificial groundwater recharge), where rainwater, surface water and/or reclaimed water is routed to the subsurface. Artificial groundwater recharge aims at the increase of the groundwater potential. This is done by artificially inducing large quantities of surface water (from streams or reservoirs) to infiltrate the ground. It is commonly done at rates and in quantities many times in excess of natural recharge. The number of aquifer recharge and re-use schemes in Europe, and around the world, has expanded in recent years. The primary driver for this expansion has been the increasing demand for water to meet agricultural, industrial, environmental, and municipal needs. In southern Europe, the uptake is predominantly motivated by agricultural and municipal water needs, whereas in Northern Europe groundwater recharge is mostly found in densely populated areas for use in households (e.g. Berlin, The Netherlands).

Dams and reservoirs for **water storage** can be potentially used in most water scarce areas, where water efficiency measures can't fully resolve the problem. A dam is a barrier that produces changes in the hydro-morphological and physico-chemical conditions of the impounded river. River damming is one of the most ancient techniques used for water supply. Large dams have long been promoted as providing "cheap" hydropower and water supply, reducing also flood impacts to populated floodplains. A reservoir is natural or artificial pond or lake used for the storage and regulation of water. Reservoirs may be created in river valleys by the construction of a dam or may be built by excavation in the ground or by conventional construction techniques. These measures, in general, are considered more expensive and might have significant negative impacts to the environment.

There are two types of **water re-use**: direct and indirect. Direct wastewater re-use is treated wastewater that is piped into a water supply system without first being incorporated in a natural stream or lake or in groundwater. Indirect wastewater re-use involves the mixing of reclaimed wastewater with another water supply source before re-use. The mixing occurs for example when the groundwater is too saline and needs to be improved by the treated waste water. Re-use of treated wastewater is a valuable resource for water supply in areas where water is limited. It has the potential to become an alternative source of water after relevant treatment. It could be used for irrigation in agriculture, industrial uses and specific uses in buildings provided that all relevant safety standards are respected. Re-use of treated wastewater is an accepted practice in several European countries with limited rainfall and very limited water resources, where it has become already an integral effective component of long term water resources management. However, only a few countries developed comprehensive reuse standards. Strict quality controls to minimise the risk of environmental contamination and human health problems due to water re-use. In addition, proper household metering and water pricing strategies are important drivers for the implementation of water reuse systems.

Rainwater harvesting is the process of collecting, diverting and storing rainwater from an area (usually roofs or another surface catchment area) for direct or future use. This is a technology that can be used to supply water to agriculture, households and industry.

2.2.2. Key information on the cost-effectiveness (risks and benefits)

In theory alternative water supply options, especially desalination, can deliver unlimited amount of water. In practice all the options have a lot of limitations in terms of costs and negative economic, environmental and social impacts. Cost-effectiveness of the options is as follow:

Desalination plants involve high capital costs, maintenance and operational costs and recurrent costs, because of its reliance on high energy requirements and if its location is far from urban areas a distribution network needs to be installed to transfer desalinated water to the mains water supply. It affects the cost-effectiveness of desalination bringing high desalination costs (0,21 – 1,06 Euro/m3). Distribution costs of desalinated water: to transport 1 m3 of water is estimated at 0.037 € per 100 m of vertical transport and 0.043 € per 100 km of horizontal transport. Other costs, related to the pre-treatment and the concentrate disposal, has to be also considered within the desalination process. Miller (2003) estimates pre-treatment costs to account for up to 30% of O&M costs while Younos (2004) estimates the costs of brine disposal between 5 to 33% of total desalination costs (Ecologic, 2008).

Development of the water transfer infrastructure involves very high costs. Example from England: the capital cost of water transfer infrastructure (to meet demand for water in south east England) is estimated to be between £8 million to £14 million per megaliter, which is 4 times more than developing new resources in south east. To transport 1 m3 of water is estimated at 0.037 € per 100 m of vertical transport and 0.043 € per 100 km of horizontal transport (EA 2006).

Concerning water recharge costs of water supply are lower than in the case of desalination or water transfers. It is mainly owing to lower investment, treatment and distribution costs. In the Belgian case study cost of producing water from ground water recharge was estimated to be 0.5 €/m³, which was cheaper than transferred water from outside the region (0.77 €/m³) (in 2007) (TYPSA 2012). There is no need of large storage structures to store water. Structures required are mostly small and cost-effective and less evaporation losses are produced. An extensive and expensive tertiary treatment is required for using waste water to recharge ground waters (although in most situations in the EU these are in place in any case). Strict quality controls to minimise the risk of environmental contamination and human health problems are needed, what entails costs, which should be taken into consideration.

Costs effectiveness of storage reservoirs seems to be the most expensive water supply option. In UK costs of winter storage reservoirs are calculated as follows: lay-lined reservoirs: €3.20/m3 to 6,70 EUR/m3, Reservoirs with a synthetic liner: 4,90 EUR/m3 to 15,80 EUR/m3, including energy (CO_2) from pumping twice (from borehole/river to reservoir; and from reservoir to field) (BIO 2012). In Australia case study expanding reservoir capacity costs were estimated on AUD 2,40/ kL (OECD 2011). However overall benefit (to farmers) of moving to irrigation reservoirs is estimated at 14 EUR/m3 to 27 EUR/m3 as well as additional (non-monetised) benefits associated with improved security and flexibility of supply (case study from UK) (BIO 2012). Those benefits should be taken into account while considering water supply alternatives.

One of the most cost promising water supply alternatives is water recycling. The capital costs are low to medium for most wastewater re-use systems and are recoverable in a very short time. Experience from Australia: cost of recycling urban storm water (for non potable) – AUD 1,20-2,00 /kL; (for potable) – AUD 1,30-1,70 /kL; recycling treated sewage water – non-potable AUD 1,90/kL; potable AUD 2,50/kL (OECD 2011). Costs of waste water irrigation even tend to be lower than for groundwater irrigation, because the pumping effort needed is lower. However wastewater re-use may not be economically feasible if it requires an additional distribution network and storage facilities. Strict quality controls to minimise the risk of environmental contamination and human health problems are needed, what entails costs, which should be taken into consideration.

Total treated wastewater life cycle cost converted into €/m3 (TYPSA 2012):

Reuse alternative	**Recommended treatment process**	**Annual costs (€/m³)a, b**
Agriculture	Activated sludge[4]	0.16-0.44
Livestock	Trickling filter	0.17-0.46
Industry and power generation	Rotating biological contactors	0.25-0.47
Urban irrigation – landscape	Activated sludge, filtration of secondary effluent	0.19-0.59
Groundwater recharge – spreading basins	Infiltration – percolation	0.07-0.17
Groundwater recharge – injection wells	Activated sludge, filtration of secondary effluent, carbon adsorption, reverse osmosis of advanced wastewater treatment effluent	0.76-2.12

Cost effectiveness of rain water harvesting is related to the need of financing the capital investments and operation/maintenance costs for relatively large storage tanks in situations where there is a poor rainfall distribution. These cost are relatively high as presents experiences from different countries: Australia - cost of rain water tanks – AUD 3,75/kL (OECD 2011); in Belgium a RWHS for private households requires a large investment and the price reaches the value of around €1.8 to 4/m³ of RW used. The regulation specifies minimum requirements that aim at a cost-efficient introduction of RWHS. On the other hand, the savings amount to €1.7/m³ for avoided use of mains water. As with current regulations, the costs for sewage and sewage treatment are recovered on the basis of m³ of mains water used, the RW user benefits from an additional €2/m³ for avoided costs for sewage and sewage treatment; in Malta the estimated cost of using the water produced by a RWH system reaches the value of €5 to 11/m³ depending on the varying construction costs.

[4] Could also be natural low-cost treatment systems such as stabilisation ponds, constructed wetlands, or other like trickling filter, rotating biological contactor (footnote 16 in the IA of the Blueprint).

According to expertise the water saving potential for measures which are associated with rain water harvesting (rain water flowing from a roof is transferred via a pipe to a container in order to be used, for example, for gardening or car wash activities) is expected to meet up to 80% and 50% of households needs in France and UK, respectively (ACTeon et al., 2012). Concerning water harvesting in agriculture the overall benefit (to farmers) of moving to irrigation reservoirs can be estimated at 14 EUR/m3 to 27 EUR/m3 (discounted over 25 years at 4%), or annualised benefits of 0,80 EUR/m3 to 1,55 EUR/m3 per year (BIO 2011).

Economic impacts

- Provision of adequate and reliable water supply in urban areas encourages general economic development;
- Guarantee of water supply during peak water demand periods (e.g. the tourist season), and because of its reliability it can support other and new economic activities;
- High investment and O&M costs related to treatment and distribution.
- In case of water storage reservoirs the need to devote a land, which otherwise could be used for some economic activities should be considered. The location of desalination plants also implies land-use planning issues: they are mostly located in coastal zones (already densely populated), and have impact on the value of land – "not in my back yard".
- In case of water reuse there are some additional positive economic impacts:
    - Reusing the total volume of treated wastewater in Europe could cover nearly 44.14% of the agricultural irrigation demand and avoid 13.3% of abstraction from natural sources (Defra 2011). In Israel of all sewage that is treated, 75.5% (358 Mm^3) is used for irrigation, representing 40% of the total water use in agricultural irrigation. Recently assessments point that the percentage had risen to 87% by 2007 and the objective is to reach 95% of reclaimed water by the end of the decade (Defra 2011).
    - use of the nutrients of the wastewater (e.g. nitrogen and phosphate) resulting to the reduction of the use of synthetic fertilizer and, reduction of treatment costs (reclaimed water, can be used for agricultural irrigation, landscape irrigation, industry, and non-potable urban uses). However there are some technological restraints related to crop type, presence of chemicals/nutrients not synchronized with crop requirements in using treated wastewater.

The potential of the water reuse source hasn't been exploited so far in Europe: by 2006 the total volume of reused treated wastewater in Europe was 964 Mm^3/yr, which accounted for 2.4% of the treated effluent. The treated wastewater reuse rate was high in Cyprus (100%) and Malta (just under 60%), whereas in Greece, Italy and Spain treated wastewater reuse was only between 5 % and 12 % of their effluents. Nevertheless, the amount of treated wastewater reused was mostly very small (less than 1%) when compared with a country's total water abstraction (TYPSA 2012).

Water reuse and desalinisation require a continue enhancement of technologies in order to lower the use of energy and minimize environmental impacts on the aquatic environment. This is, therefore, an area for investment in innovation to ensure the cost-effectiveness of measures. Unlike water transfers, that increase water supply in one basin, at the expense of other basins, desalination has the advantage of decoupling water production from the hydrometeorological cycle.

Rainwater harvesting can have strong economic impact by reducing water costs paid by households, agriculture or industry to pay for mains water supply. The economic potential of this supply option is estimated very high. Rainwater harvesting could save 20 to 50% of the total potable water use in a standard home, whereas grey water recycling could save 5 to 35%, as seen in the UK experience (Bio Intelligence et al., 2012). In Bedfordshire, one of the drier parts of England, the MAAF study showed that one hectare of roof area might theoretically provide sufficient water to irrigate 2,5 hectares of potatoes (at 80% efficiency).

Environmental impacts

All alternative sources of water supply reduce the demand on mains water supplies and reduce pressure on environment.

Most of alternative supply options are related to the intensive use of energy. Among them the most energy consuming is desalination. If the energy is from using the use of fossil fuels, this will increase GHG emissions. This is linked to the higher amounts of energy needed to desalt water (between 3.5 and 24 kWh/m3 according to the technology), especially with thermal processes. On the basis of an average European fuel mix for power generation, it has been estimated that a revers osmosis plant produces 1.78 kg of CO2 per m3 of water, while thermal multi stage flash leads to 23.41 kg CO2/m3 and multiple effect distillation to 18.05 kg CO2/m3 (Ecologic 2008).

Example from Spain: it was estimated the desalination installation at Carboneras – Europe's largest RO plant - uses one third of the electricity supplied to Almeria province. The more than 700 Spanish desalination plants produce about 1.6 million m3 of water per day. According to the estimates (1.78 kg of CO2 per m3 of water) on CO2 production from desalination, this translates into about 2.8 million kg CO2 per day. It can be argued therefore that desalination is contributing significantly to Spain's overall GHG emissions, which have been skyrocketing to +52.3% in 2005 compared to 1990 levels – moving Spain well beyond its European burden sharing target of +15%. This may be a foretaste of the dilemmas that will face other Member States in future years as the impacts of climate change are felt increasingly widely (Ecologic 2008).

Other environmental impacts of desalination varying severity depending on local conditions are on the aquifer and on the marine environment as a result of the concentrated brine management and water treatment and plant maintenance activities, water intake activities, and noise.

Water transfers and water supply projects, such as the construction of reservoirs and dams or irrigation schemes have significant negative environmental impacts in terms of biodiversity, wetlands, water availability and environmental flow. There are big uncertainties regarding how much water will be able to be transferred in the future.

Additionally construction of reservoirs and dams or irrigation schemes, can have negative consequences on biodiversity, especially in water scarce areas. As an example, planned irrigation schemes in the water poor Ebro basin in Spain were linked to significant declines in bird distribution (ACTeon et al., 2012). It is contributing as well to the discontinuity along the river, impeding fish species to reach their spawning grounds and is responsible for blocking of sediment transport to the sea is the main responsible of deltas and beaches regression.

Groundwater recharge reduces the threat of over-exploitation of existing aquifers, and decreases the risks of seawater intrusion into aquifers at or near the coast. It guarantees available for both the economy and the environment surface and groundwater resources during summer and drought periods. Fewer evaporation losses are produced, contrary to dam or impoundment alternatives, that in southern countries could reach levels up to 1m/year (TYPSA 2012). In the contrary it reduces pressure on water bodies from reduction in summer abstractions.

Waste water reuse not only reduces the demands of freshwater, but can also reduce the pollution of rivers and groundwater by nutrients. From another side if there is no strict quality controls, there could be the risk of environmental contamination and human health problems (water-borne diseases and skin irritations).

The direct waste water reuse in households results in increased GHG emissions in existing homes, whereas its installation in new homes, alongside with other water efficiency measures, shows net carbon benefits. Different biological and bio-mechanical systems apply to single residential dwellings, commercial buildings or multi-use buildings. These systems have different operational energy and carbon intensities. For grey water reuse, the latter range from 0.6 kWh/m3 for short-retention to 3.5 kWh/m3 for small membrane bioreactors (Bio Intelligence et al., 2012).

The same environmental impact concerns rain water harvesting. The need of construction and maintenance of the necessary infrastructure may lead to negative energy/treatment/GHG impacts. The retrofitting of household rainwater harvesting results in increased GHG emissions in existing homes, whereas its installation in new homes, alongside with other water efficiency measures, shows net carbon benefits. Different biological and biomechanical systems apply to single residential dwellings, commercial buildings or multi-use buildings. These systems have different operational energy and carbon intensities. For rainwater harvesting, the latter range from 1.0 kWh/m3 for direct feed to 1.5 kWh/m3 for header tank (Bio Intelligence et al., 2012). For water harvesting in agriculture the same negative effects should be taken as those identified for water storage (dams and reservoirs).

The positive environmental impact of rain water harvesting is the reduction of the amount of urban storm runoff due to its buffering effect on storm events, which in turn reduces the amount of pollutants being washed into surface waters that are used to recharge shallow groundwaters.

Social impacts

In general alternative water supply alternatives provide adequate and reliable water supply in urban areas and encourage general economic development and job creation.

Water transfers provide right distribution of benefits between the area of transfer origination and area of water delivery. However by contributing to the development of regions without adequate local water supplies it may limit future development (economic productivity) in the area of the transfer's origin. It can cause problems of inter-regional or international fights for water rights, as drought extreme events are complex to manage.

Water storage change land use in the region, which can lead to low social acceptance.

The general public or specific groups may refuse to consume products that are associated with the waste water re-use – the so called "yuk" factor.

There is the potential for impacts on health arising from these options (which would be stronger with a regulatory approach). These impacts would depend on whether building standards included requirements for re-use of water within the buildings (which would, therefore, need to be subject to subsequent IA if this were proposed). Reduced water flows can result stagnate in pipes, leading to microbial growth, although this concern is largely theoretical at present and currently design and control have reduced this problem. With regard to rainwater harvesting and to grey water reuse health issues are linked especially to installation, maintenance and operation of these sources. Stored rainwater can be contaminated with Enterococci (EUREAU 2011b). Also, back-wash systems (as part of the design of a reuse system for maintenance and cleaning) could contaminate drinking water supplies.

Having said this, public perceptions of possible health impacts are a barrier. Actions to control water quality include health codes, procedures for approval of service, regulations governing design and construction specifications, inspections, and operation and maintenance (US EPA, 2004) and standards have been adopted in national law (e.g. France, Spain and UK) for rainwater harvesting and grey water re-use to address this issue.

Poorer families will not have the financial resources to invest in the technology of water harvesting, and reap the benefits of lower water costs. The same concerns tenants who will not have the opportunity to reap the benefits of lower household water costs, as landlords do not benefit from this type of investment.

2.2.3. Barriers for implementation

Market failures, regulatory and policy support

There is the lack of the application of best practices in integrated water management by water managers at a national or basin level to produce RMBPs that are coherent and cost effective. In general at a national or basin level the institutional or administrative structures are not in place. It causes problems in the development and implementation of an integrated water resource management plan for the administration, management, protection and sustainable development of the raw water resources at a basin and water body level.

The existing RMBPs hardly apply the principles of: polluter pays, cost recovery, cost effectiveness and disproportionate costs. It means that they do not meet society's overall water objectives for quality and quantity i.e. a RBMP that is harmonized with socioeconomic development objectives resulting in water bodies that will achieve good ecological status.

There is the lack of coherence between the RBMPs and other sectorial plans resulting in inability of basin mangers to fully evaluate the costs and benefits between measures in order to select the most cost effective ones for society. For example: there is lack of sufficient linkage with related policies such as CAP, land-use planning; artificial water storage very often is not in line with rural development rules and existing legislation (too strict existing standards).

There is a general lack of clear institutional roles between water resource managers (responsible for quantity and quality) and competent authorities for environment whose focus is on water quality and the environment. The efficient and cost effective management of water resources requires the management and implementation of measures that are for the common and cost effective good of multiple users and are not solely linked to one user or user group. This requires an institutional framework with the capacity to administrate, evaluate, select and manage the implementation of common water resource.

Lack of full cost recovery of water services, including financial, environmental and resource costs makes difficult to take economically and environmentally sound decisions on the choice of best water supply option.

There is lack of guidelines or criteria for water reuse taking into account regional characteristics. The absence of an EU regulatory framework presents a significant barrier as standards commonly agreed terminology are the basis for the success of water reuse projects.

The lack of standards has caused administrations to take a rather conservative approach and has led to mistrust and misunderstandings regarding users who do not have of trust, credibility and confidence, especially in the agricultural sector. In some countries the governing standards put unnecessary limits on the use of the treated waste water or led to illegal uses.

Lack of financing is considered the single most significant barrier to wider use of reclaimed wastewater.

Reclaimed water is not the only source available for groundwater recharge, also water excess due to floods or wet periods are available to be naturally (ponds) or artificially (wells) injected. When treated wastewater (expensive tertiary treatment is needed) is used for groundwater recharging there is a need to have strict controls to ensure that no pollution problems to the groundwater bodies appear.

Financing sources

Lack of financial incentives and of sufficient information on the available techniques, best practices and the benefits of using treated waste water or harvested rain water put limits to the use of these alternative water sources.

Important barrier to the implementation of alternative water sources are the high costs associated with them. When current water supply is provided from cheap local sources (groundwater or surface water), water produced by desalination or ground water recharge are likely to be more costly. In these cases it is not financially obvious to introduce these water supply options, especially if the current water prices do not reflect all the economic costs, nor the environmental and resource costs. Costs per m^3 water produced may be very different for similar technologies or supply options in the different Member States that implies that the barriers for implementation vary country by country.

Lack of implementation and coordination

There is a need of a high quality monitoring system and quality assurance for consumer's acceptance (concerns especially water reuse, water recharge and rain water harvesting).

Desalination can be a replacement for potable water supply purposes, although its supply regime is rigid and inflexible, and so is best suited for supplying a fixed amount of water (according to its design specifications). There are, particular environmental and economic concerns about the high energy requirements of the desalination process, meaning that mitigation measures are needed to either improve efficiency or incorporate the use of renewable energy resources. In addition, there are also concerns about the impact on the environment of disposing brine – meaning that adequate mitigation measures have to be incorporated to deal with brine disposal. These concerns are an opportunity to develop new technologies, that more efficient, with less environmental impact.

There are problems to find available land for construction of big desalination plants.

Knowledge base

In the context of river basin planning, water reuse options tend to be excluded or forgotten as stakeholders are not well informed about the link between water supply and wastewater treatment. As such, research results from feasibility studies on water use have not been taken up in practice, especially in areas where water supply and wastewater are managed by different companies or agencies.

Interbasin water transfer proposals needs thorough evaluation to determine if they are justified considering all associated impacts. There are uncertainties concerning water availability in the future (how much water will be available to be transferred).

Investments in artificial water storage and the creation of new resources should be based on economic analysis. They usually bore high investment, maintenance and operation costs, long investment procedures and significant potential impacts on the environment that have to be taken into consideration. They should be considered as an option when other options to improve water efficiency, including the application of economic instruments have been implemented.

2.2.4. Degree of implementation as reflected by the RBMPs

The development or upgrade of reservoirs or other water regulation works is included in about 30% of the RBMPs, development or upgrade of water transfer schemes in 23%. Measures to foster aquifer recharge are included in 33% of the plans.

The development or upgrade of desalination plants (in about 1% of the plans) and the establishment of water rights markets or schemes to facilitate water reallocation (in about 2% of the plans) are the least considered.

There is little quantitative information on the waste water reuse. While at EU level water reuse amounts to less than 1% of the countries' total water abstraction, in Cyprus and Malta the treated wastewater reuse rate of their effluents is high (respectively 100% and 60%) (TYPSA 2012). This currently under-exploited measure has a high potential. Nevertheless treated waste water reuse and rainwater harvesting are not identified as main measures in the RBMPs. According to the preliminary analysis of RBMPs there were no measures related to WWR and RWH included in almost 50% of the assessed RBMPs.

2.2.5. Key EU policy instruments that would unlock / guide the implementation

EU Policy instruments related to use of economic instruments

Economic incentives could help in "unlocking" the measures. This supposes the proper implementation of the WFD economic principles of polluter-pays principle, the principle of cost recovery, including environmental and resource costs. Alternative water supply is more costly than conventional sources, especially if water prices do not cover all costs. It may be difficult to introduce the measures without **economic incentives** such as temporarily applied subsidies.

While choosing the best water supply option economic analysis taking into account full cost recovery of water services, including financial, environmental and resource costs should be the base to take economically and environmentally sound decision.

EU Policy instruments related to governance and integration

To strengthen the "quantitative dimension" of the WFD implementation by establishment of systematic water balance assessment/water accounts at sub-catchment level and the dynamic modelling of water resources for the preparation of next RBMP. This will provide information on where and how water efficiency can be improved and which alternative water supply sources should be developed in a cost-effective way.

Water reuse:

The key recommendation of the Mediterranean Component of the EU Water Initiative (MED EUWI) Wastewater Reuse Working Group is to develop a commonly agreed European and Mediterranean guidance framework for treated wastewater reuse planning, water quality recommendations, and applications.

Awareness raising campaigns and advisory services could improve the public and user awareness and acceptance of the water reuse. Improve implementation of cost recovery and provision of economic incentives to promote and make water reuse cost effective.

Other sources:

The application of desalination and artificial recharge could be facilitated by improving the political and public acceptance. Prior to starting such type of new investment an awareness raising campaign and extensive consultation with the stakeholders and public should be carried out. This should be combined with a high quality monitoring system for ensuring their safe use and improving consumers' acceptance.

Since desalination facilities might have significant negative impact on the environment the inclusion of these facilities under the scope of the IED (2010/75/EU) and EIA (85/337/EEC) Directives should be considered.

EU Policy instruments related to funding

Implementation of alternative water supply measures requires high investment costs, so potentially they can enter to the scope of EU funds financing. As they can trigger substantial economic, environment and social impacts, there should be introduced strict assessment procedures to allow their implementation and financing, only while efficiency measures are fully addressed and can't resolve water shortage problems.

EU Policy instruments related to knowledge base

Further research and innovation activities:

- To get cost efficient and more environmental friendly techniques and technologies available for desalination technologies.
- To develop available techniques, best practices and the benefits of using treated waste water or harvested rain water.
- To adapt water markets.

Annex 2 - Synopsis report on consultation activities

I. Introduction

The consultation process for a possible new EU initiative on water reuse began in 2012 and continued until July 2017 in various forms, both organised and ad hoc. The implementation of the consultation strategy involved collecting and analysing input from a wide range of stakeholders as well as two online public consultations with the aim to:

(1) Provide an opportunity to express views on the present and potential development of water reuse in the EU, on the opportunity to further promote water reuse in different kinds of sectors and on possible/desirable actions that could be taken at EU level;

(2) Gather specialised input (data and factual information, expert views) on specific aspects of the benefits and barriers affecting the development of water reuse (e.g. available treatment techniques and related costs, existing and planned legislation in Member States, risk management approaches etc.) with the aim of filling the data and information gaps in view of refining the policy options and preparing the impact assessment.

The following identified stakeholders' categories have been targeted in consultation activities:

- Scientific Committees [European Food Safety Agency (EFSA) and Scientific Committees Scientific Committee on Health, Environmental and Emerging Risks (SCHEER)])
- EU Member States and public authorities responsible for water management
- Water users, in particular representatives of the farming sector
- Water industry, both water supply and sanitation and suppliers of technology
- NGOs active in the water area
- Academia and experts, research and innovation organisations
- Citizens and the general public;
- As well as other EU institutions

This document summarises the various contributions received[5] and, based on the analysis of this input, identifies issues that stakeholders regard as priorities when further developing water reuse at EU level. These findings have been used in the preparation of the impact assessment and the updating of the scientific basis of the proposal (the JRC report in Annex 7) and will further be used to inform the decision-making process in view of a new instrument to regulate specific aspects of water reuse at EU level (agricultural irrigation and aquifer recharge).

In the consultation process, stakeholders also put forward a number of suggestions going beyond the current scope of a possible instrument on water reuse at EU level and these will be taken into consideration in future exercises addressing other aspects of water reuse.

[5] http://ec.europa.eu/environment/water/reuse.htm

II. Consultation results by activities and stakeholder group

Scientific Committees

To ensure the proposal will be based on up-to-date scientific knowledge and will provide the appropriate level of safety as regards human health and the environment, EFSA and SCHEER were consulted on the penultimate version of the technical report developed by the JRC (December 2016) which is mentioned above.

EFSA approved its technical report on 22 May 2017. It reviewed whether the methodology used was appropriate, the defined food crop categories were appropriate, the proposed minimum quality requirements were sufficient, and any risks had been overlooked. Following its analysis, EFSA issued recommendations[6].

SCHEER delivered its scientific advice on 9 June 2017. It examined four questions: Is the methodology used by the JRC considered appropriate? Do the proposed minimum quality requirements provide sufficient protection against environmental risks that may be associated with water reuse for agricultural irrigation and aquifer recharge? Do the proposed minimum quality requirements provide sufficient protection against human health risks that may be associated with water reuse for aquifer recharge? And have any risks been overlooked? The SCHEER concluded that, while the methodology chosen was appropriate and the report considers many important elements, the document is deficient in key details[7].

The opinions of the two scientific Committees have been duly taken into account in the finalisation of the technical content of the proposal and its assessment in terms of health and environmental impacts.

Consultation of experts in Member States and stakeholder organisations

Consultation took place in the framework of the Common Implementation Strategy (CIS) for the implementation of the Water Framework Directive (WFD). Water reuse was discussed in 6 meetings of the former Working Group on the Programmes of Measures (September and November 2013, March and October 2014, March and October 2015). A dedicated activity on water reuse and an Ad-hoc Task Group (ATG) was included in the CIS work programme for 2016-2018 to accompany the development of related actions.[8]

EU Member States and public authorities responsible for water management

[6] The EFSA opinion published on 10 July 2017 is available at http://onlinelibrary.wiley.com/doi/10.2903/sp.efsa.2017.EN-1247/epdf

[7] https://ec.europa.eu/health/sites/health/files/scientific_committees/scheer/docs/scheer_o_010.pdf

[8] Information on the status of water reuse in EU Member States was collected and participants were invited to feedback on draft versions of the IA support studies elaborated by consultants. A technical workshop on possible minimum quality requirements on water reuse at EU level was organised by DG ENV and JRC in June 2015. Meetings were held in March 2016, October 2016 and June 2017 and specifically discussed draft versions of the JRC technical report. Draft elements of the impact assessment were also presented in order to collect feedback and gather additional information. Expert Groups on the Groundwater Directive, the EQS Directive, the UWWTD and on the Drinking Water Directive were also consulted.

During the detailed discussions held with Member States' experts, broad support for the concept of water reuse was overall apparent, with some notable exceptions. Representatives of those Member States currently already practicing water reuse in the relevant areas (agricultural irrigation and aquifer recharge) have generally been more in favor. These include notably Spain[9] and Italy[10] but also others (Cyprus, Malta, Portugal, and Bulgaria). France has also expressed its support for an EU legal instrument.

Despite the political support expressed by the Council (see above), some Member State representatives at technical level have expressed certain reservations about the initiative. These include Germany[11], Austria[12] and the Netherlands[13]. At the latest meeting of the CIS ATG on Water reuse, broad support for the EU initiative on water reuse was expressed. Support for a legal instrument was particularly strong from Member States currently already facing water scarcity and severe impacts of droughts and climate change. There were also some positions expressed concerning the type of EU instrument, and a few Member States seemed to prefer a Guidance document to an EU legal instrument as a starting point.

Consultation of water users (in particular farmers)

The farmers' association at EU level (COPA-COGECA) participated in the expert group exchanges and issued a position in writing and participated in various conferences. They were overall appreciative of the concept, stating that it will contribute to a more resilient farming sector, help overcome pressures deriving from climate change and, in upcoming years, be not only an alternative supply option but rather the most important source of clean water. Challenges highlighted were the need to identify the right quality of water, whereby the minimum quality requirements must take into account specific local needs and give flexibilities to the regions and Member States. Reclaimed water for irrigation should be nutrient-free as well as particle-free. Affordability of the proposed water reuse schemes should be carefully considered. COPA-COGECA further indicated that the compliance should be at the point where reclaimed water is discharged by the treatment plant. Finally, any new

[9] Spain indicated its support and noted that as the objective is to promote rather than to prevent water reuse, the legislation should be safe but also practical and manageable; in particular, there is a need to properly reflect on the feasibility of the proposed minimum quality requirements. According to the Spanish experience setting limit values for chemicals is challenging, also for those which can be crop nutrients. This should not prevent but incentivise their recycling. The validation requirement proposed by the JRC for quality class A is considered unrealistic; the proposed parameter is not technically appropriate and would also strongly disincentive existing water reuse practices in ES.
[10] Italy expressed support while indicating that the final instrument has to be realistic. Italy informed that there is currently no practice with aquifer recharge, however a strong interest for the future. In relation to minimum quality requirements for this purpose, parameters for chemicals (CECs) should be introduced as there is a risk of contamination. The JRC report was considered a very good basis for a potential EU instrument on water reuse.
[11] Germany indicated that water reuse is currently not an important issue in Germany (there are as of yet only 2 sites where water reuse for irrigation is practiced) and considers there is no need for a binding instrument on risk management at this stage. The practical implementation of the instrument on water reuse was unclear. For aquifer recharge a guidance document would be sufficient. For agricultural irrigation, the current minimum standards proposed by JRC were not stringent enough.
[12] Austria felt that for obvious reasons water reuse is not high on the agenda in Austria and it is considered that the existing water acquis is currently sufficient to address this issue. Concerning the risk management framework, a guidance document was considered as the most appropriate response and in relation to CECs, Austria supported very much a holistic approach beyond the specific issue of water reuse.
[13] The Netherlands referred to existing legislation being sufficient enough to address the problem; the EC initiative not fully complying with the Better regulation principles and finally the scope of the initiative being too narrow, whereas the Netherlands would rather appreciate a focus on integrated water management.

instrument should be light and not inflict administrative burden. It should only apply to those practicing reuse.

Water industry, both operators of water services (water supply and sanitation) and suppliers of technology for water treatment

The initiative is of interest to both operators of water services (water supply and sanitation) and suppliers of technology for water treatment – e.g. European federation of national associations of drinking water suppliers and waste water services (EUREAU), Water supply and sanitation technology platform (WSSTP), European Centre of Employers and Enterprises providing Public services (CEEP), European Irrigation Association (EIA), European Water Association (EWA);

Positions taken by industry representatives have generally been supportive; they were aware of the potential of harmonizing quality standards on water reuse for technological and economic development. Water reuse is already happening in many countries and the demand for reused water will continue growing due to climate change. Technologies exist to provide safe reused water and scientific evidence shows that potential negative impacts can be mitigated. In this respect, proper risk assessment and monitoring are key tools to ensure water reuse safety. Private companies were by far the most positive across types of stakeholders about the safety of water reused compared to other sources of freshwater (groundwater or water from rivers).

The industry has, however, also highlighted a number of challenges, particularly potential legal constraints and administrative burden related to the development of water reuse, as well as the cost of implementation. They also mentioned the low price of freshwater compared to reused water. For example, EUREAU, while overall supportive of the work on water reuse, felt that possible EU requirements cannot be a "one size fits all" solution and must not be imposed on Member States. In particular, they must reflect different water quality levels depending on the intended use of treated water. It must remain economically viable on top of protecting human health and the environment. Industry has also requested that the issue of liability be clarified in a possible new instrument.

NGOs active in the water area (including European Environmental Bureau; WWF)

NGOs were generally supportive of the concept and work. They were, however, concerned with the safety of reclaimed water and felt that a possible new EU instrument would need to set minimum criteria that are stringent enough to ensure the needed protection of the environment, as well as human health.

Consultation of academia and experts, research and innovation organisations

Within the European Innovation Partnership (EIP) on Water, several action groups set up in recent years address water reuse, such as: Industrial Water Reuse and Recycling (InDuRe), Water & Irrigated agriculture Resilient Europe (WIRE), Real Time Water Quality Monitoring (RTWQM), Verdygo - modular & sustainable wastewater treatment. The European Technology Platform for Water (WssTP) initiated by the Commission is also very active on water reuse with a dedicated multi-stakeholders working group on water reuse. These groups have been regularly informed about the initiative and invited to provide feedback on the technical development of the proposal.

Representatives of academia and experts were strongly in favour of EU action for water reuse for agricultural irrigation; however an EU action on aquifer recharge has not been supported by all. They demonstrated particular interest in the approach that would be chosen concerning risk perception and the proper protection of public health and the environment. A preference for a risk-based approach as a key element to build trust and confidence was also voiced. Other important elements were management practices, transparency and involvement of the public.

Representatives of the research and innovation community had a preference for mandatory EU minimum quality requirements which were seen as innovation-friendly if certain conditions, such as the balanced scope of water quality parameters and stringency of limit values, are met. They would boost R&I at all phases driven by the needs to demonstrate technical performance, efficiency and reliability of conventional and new technologies (filtration, disinfection, membranes, advanced oxidation, etc.), economic viability of water reuse projects, and social and environmental benefits. In addition, new and innovative ways of monitoring would be stimulated.

EU institutions

The Commission communicated to the Council and the Parliament its intention to address water reuse with a new initiative in two Communications (COM(2012)673) and COM(2015)614). The ***Council*** provided feedback in its conclusions on these two Communications. It further elaborated on its expectations as regards the proposal in its Conclusions on Sustainable Water Management (11902/16) under the Slovak Presidency (17 October 2016) which state that the Council

"EMPHASISES that water re-use, in addition to other water saving and efficiency measures, can be an important instrument to address water scarcity and to adapt to climate change as part of integrated water management; CALLS ON the Members States to take measures to promote water re-use practices, taking into account regional conditions where appropriate and whilst ensuring a high level of protection for human health and the environment, as water re-use can also deliver benefits in terms of economic savings, environmental protection, stimulating investments in new technologies and creating green jobs; STRESSES that well-treated urban waste water can be re-used for a variety of purposes in the agricultural sector, industrial applications, sustainable urban development and protection of ecosystems; and NOTES with interest the intention of the Commission to present in 2017 a proposal on minimum quality requirements for reused water in the EU;"

The ***Parliament*** expressed expectations as regards the initiative in its resolution[14] on the follow-up to the European Citizens' Initiative Right2Water of 8 September 2015. Like the Council, it expressed overall support to the concept of water reuse and the Commission's intention to develop a dedicated instrument; the Parliament notably "72. Encourages the Commission to draw up a European legislative framework for the reuse of treated effluent in order, in particular, to protect sensitive activities and areas". A number of events were also organised in the European Parliament by Members to discuss water reuse and the opportunity of a new EU legislation[15].

[14] http://www.europarl.europa.eu/sides/getDoc.do?type=REPORT&reference=A8-2015-0228&language=EN
[15] e.g.: Breakfast meeting "The contribution of Water to Circular Economy – Practices of reuse across Europe" in January 2016 by the EP Intergroup on "Climate Change, Biodiversity and Sustainable Development"; EP

The initiative was also considered by the ***Committee of the Regions***, which, in its opinion[16] on "Effective water management system: an approach to innovative solutions" of February 2017, states that it " supports the Commission's intention to put forward, in 2017 – as part of the implementation of the Action Plan for the Circular Economy – a proposal for minimum requirements regarding the reuse of water […], ensuring that there are no disproportionate negative effects on other sectors, such as agriculture; The Committee of the Regions also stressed that differences between regions in terms of water availability must be taken into account. There should be no obligation to reuse water unless this can be justified.***Communication on the development of the initiative***

A roadmap on the initial initiative "Maximisation of water reuse in the EU" was published in September 2015 which was further elaborated and focussed in an inception impact assessment published in April 2016. Both documents were provided with an on-line mechanism inviting to provide feedback, but none has been received.

Dedicated Internet pages have been developed on DG ENV's Website providing information on the policy context and the implementation of the action plan to promote water reuse in the EU. Both pages reference all available information (e.g. IA support studies) and are regularly updated. A functional mailbox ENV-WATERREUSE@ec.europa.eu was created and has been used to communicate with citizens and stakeholders.

A public relations campaign was launched in January 2017 with the aim to effectively inform about, explain, promote and increase awareness and support of the EU initiative on water reuse as part of the circular economy (CE) package. This campaign was targeted to a few EU Member States selected for their interest (countries already practicing water reuse) and influence (countries that are active in the process of defining an EU action on water reuse with regard to the initiative, tentatively: Belgium, Cyprus, France, Germany, Greece, Italy, Malta, the Netherlands, Portugal and Spain. The target audiences are policy-makers and key stakeholders (water service operators, farmers and operators in the food supply chain, water intensive industries, NGOs etc.).

A Green Week session on Water Reuse took place on 5 June 2014 with the aim to present the Commission work on water reuse, the US Guidelines on water reuse, the agricultural sector's view on water reuse and the innovation potential of water reuse practices. Water reuse was showcased again in the Green Week 2017 in a session focusing on green jobs and skills in the water sector, with the objective to demonstrate how development and implementation of EU environmental policies benefits people and the economy by creating green jobs.

III. Horizontal assessment

This section is a horizontal assessment of the views of those consulted on the need for EU action and the scope and level of ambition of a potential new EU-level instrument, mainly based on the results of the two online public consultations.

A first internet-based public consultation ran from 30 July to 7 November 2014 to gather wider feedback from the interested public and the expert practitioners across the EU. In total, 506 respondents participated in the consultation. This included: 224 individual respondents,

Water Group Plenary Session 'Water in the Circular Economy' in January 2016; EP Water Group meeting "Water Reuse Models" in October 2013

[16] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016IR3691&from=EN

222 companies and organisations, 43 public authorities and 17 other respondents. Twelve stakeholders uploaded additional documents and eight sent more detailed responses or position papers via email. Participation was particularly high in four Member States (France, Spain, Italy and Germany), which together made up more than 65% of total responses. About 95% of total answers were obtained from Member States' organisations, 3% from EU-level organisations and 2% from other countries. Among private companies, nearly equal share of respondents represented large companies and Small and Medium Enterprises (SMEs).

A second internet-based public consultation ran from 28 October 2016 to 27 January 2017 and focused on the more detailed policy options to set minimum requirements for reused water for irrigation and groundwater recharge.

In total, 344 respondents participated in the consultation. Responses were received on-line from 103 individuals (30% of respondents) and 239 stakeholders or experts (70% of respondents). Respondents represented a variety of stakeholders groups, economic sectors and countries:

- **Type of stakeholders:** Private companies, water utilities and providers and industry or trade associations represented more than a third of total respondents, a similar proportion to citizens. Public authorities represented 12% of respondents, respondents from academic/scientific/research field represented 9% and NGOs and international bodies represented less than 5% of respondents.

- **Economic sector:** Organisations involved in sanitation and/or drinking water sectors represented half of the respondents. About 20% of respondents reported to be involved in the environment and climate sectors, while only 10% represented the agriculture sector. Food industry, health and economics sector had even lower response rates compared to previous categories (each less than 5% of respondents),

- **Countries:** The large majority of responses were received from within the EU (98%). Half of the responses were provided by three Member States: Spain, France and Germany with particularly high contribution from Spain (more than one quarter of all participants). Twenty countries provided ten answers or fewer.

After both online consultations a dedicated stakeholder meeting was held (on 4 December 2014 and in March 2017); draft results of the analysis were discussed with stakeholders and additional contributions were collected. The reports on the public consultations are available at the Website of the initiative mentioned above.

A. The need for EU action

Perceived benefits of water reuse

There is a wide perception among respondents of the benefits of reusing water for irrigation or aquifer recharge purposes with regards to the availability of water resources, in the context of water stress or scarcity, unsustainable abstractions and climate change (perception from more than 70% of respondents across and within different categories of respondents). The potential contribution of water reuse to the quality of water bodies, through preserving groundwater from salinization and reducing pollution discharge from urban waste water treatment plants, into rivers, is perceived by a large number of respondents as well. Furthermore, water reuse is also perceived by a number of respondents as a means to increase resource efficiency, foster innovation and contribute to soil fertilisation, although these benefits were considered more moderate compared to the former ones. Several respondents - in particular from the health, environment and agriculture sectors - expressed their concern about the difficulty for water users (in particular farmers) to accurately estimate the amounts of nutrients present in the reused water to fully benefit from nutrient recycling and prevent risks of environmental contamination.

On the other hand, respondents are much less inclined to perceive cost savings for authorities, increased revenues, or energy and carbon savings as benefits of water reuse.

The analysis per category of respondents shows in particular that:

- countries regularly exposed to water stress and countries from Southern EU perceive significantly more and higher benefits than other categories of respondents,
- large consensus is found about these benefits within the respondents from the sanitation, drinking water, environment and economics sectors.

Perceived barriers

The main barriers to water reuse as identified by respondents are similar for water reuse in irrigation and aquifer recharge. They primarily include:

- the negative connotation of water reuse (perceived as a high or medium barrier by about 80% of respondents), including lack of awareness of costs and benefits of reuse schemes
- barriers related to policy or governance, including insufficient clarity in the regulatory framework to manage risks associated with water reuse or insufficient consideration for water reuse in integrated water management (nearly 90% of respondents perceived them as high or medium regarding irrigation and over 80% regarding aquifer recharge),
- economic barriers, including the low price of freshwater compared to that of reused water (especially in countries not affected by water scarcity) and the high cost of treatment for production of reused water (perceived as a high or medium barrier by about 80% of respondents) and fear of potential trade barriers in the case of irrigation.

In the specific case of irrigation, the distance between waste water treatment plants and irrigation fields is also seen as a key barrier (2nd most pointed out by respondents). In addition to recognising different barriers listed in the consultation, some respondents or participants to the Stakeholder meeting also expressed their concerns regarding potential risks for the environment of reusing water for irrigation, through the perturbation of environmental flows (e.g. limitation of river flows in regions affected by water scarcity) and the potential salinization through the reuse of waste water. In the case of aquifer recharge, additional concerns were expressed regarding risks of contamination of the aquifers and its irreversibility, due to the difficulty to remove pollutants from this water body.

On the other hand, significantly fewer respondents perceive awareness and availability of technical solutions to produce safe water as barriers, except in Eastern EU Member States.

Most barriers are perceived by respondents from Southern EU Member States and countries facing regular water stress, which practically experienced water reuse and often have stringent water reuse schemes in place.

Perceived safety of treated water reuse

There is an overall consensus amongst respondents about the safety of reused water compared to water from rivers, as nearly 70% of respondents (amongst those who had an opinion) consider reused water as at least as safe, both for irrigation and for aquifer recharge. In comparison, the safety of reused water compared to groundwater is more controversial, as 50% of respondents consider it less safe for irrigation and 44% for aquifer recharge.

These overall statistics hide in reality very different perceptions from specific categories of respondents. Some categories of respondents have a particularly positive or negative perception of reused water depending on their economic sector, type of organisations, situation of water stress or EU regions:

- respondents from Southern EU Member States and countries facing regular water stress are significantly more inclined to consider reused water for both irrigation and aquifer recharge as being at least as safe as alternative sources (rivers or groundwater) than respondents from Eastern and Northern countries, which tend to consider reused water as less safe in the same proportions;
- respondents from some economic sectors also have a particular negative perception of reused water safety, such as the health sector, for which 70% of respondents perceive reused water as less safe than groundwater for irrigation purposes;
- on the contrary, respondents from private companies show by far the most positive perception of reused water safety compared to other types of organisations, keeping in mind that they are involved at 68% in drinking and sanitation sectors.

The perception of reused water safety may also significantly differ within categories of respondents, as it is the case within the agriculture, food and environment sectors, for which no clear position could be seen based on the public consultation.

Justification of EU-level instrument

Although in the online public consultations in 2016 and 2014 over 60% to 80% of all respondents were in favour of an EU regulatory framework, there is no clear consensus across all types of respondents on the most suitable type of EU instrument - as listed in the questionnaire - to promote water reuse in irrigation and in aquifer recharge. In addition, more than 80% of respondents to the online public consultation held in 2014 considered legally binding EU minimum standards as effective to ensure the environmental and health safety of water reuse practices.

The respondents which are mostly in favour of the instrument of an EU regulation, in both cases, are representatives from private companies, from the sanitation, drinking water, food industry and environment sectors, and/or from Southern countries. Respondents from agriculture and economics sectors[17] as well as industry or trade associations show less consensus on supporting this policy option.

Overall, the option of the instrument of a Commission recommendation is the 2nd preferred policy option within and across most categories of respondents, although CEN standards are generally preferred by respondents from agriculture, food and health sectors for water reuse in irrigation. The highest level of support for the use of Commission recommendations comes from water providers/utilities and public authorities as well as respondents from Eastern EU Member States.

[17] i.e. any industrial sectors other than food, drinking water and sanitation

These results should be considered with caution, as many comments - from respondents who selected the EU regulation or Commission recommendations - pointed to the preference for an EU Directive, which was perceived to provide both sufficient level of protection to reach its objectives and adaptability to be relevant to local contexts and needs. However, this was not listed in the closed list of policy options from the public consultation and also the impact assessment did not consider a Directive as an option as it would impose requirements also on Member States which otherwise don't intend to reuse water.

B. Scope and level of ambition

Objectives of the EU minimum quality requirements for water reuse

Respondents to the public consultation identify in their vast majority (>70%) the following objectives as key for the EU minimum quality requirements for water reuse:

- For irrigation, the protection of human health of consumers through the safety of agricultural products placed on the EU market, of human health of public directly exposed to reused water, of water resources and dependent ecosystems, and of the wider environment.
- For aquifer recharge, the protection of water resources and dependent ecosystems, of human health of the public directly exposed to reused water and of future users of water abstracted from the aquifer.

These objectives are largely supported by the civil society and public authorities and are shared within and across economic sectors. They are also mostly shared within and across EU regions, except for the protection of human health of public directly exposed to water reuse in the case of irrigation, which was recognised as an objective by a lower share of Eastern EU Member States compared to other EU regions (50% vs. 70% for other EU regions).

In comparison, in the specific case of irrigation, the protection of agricultural productivity is not given as much importance (40% of respondents only think it should be covered). Yet, a large majority of respondents from the agriculture sector still considers it as an objective to be addressed by EU minimum quality requirements for irrigation (75% of respondents). A significantly higher share of respondents from Eastern EU Member States also identified it as an objective compared to other EU regions.

Specific aspects to be covered by minimum quality requirements for water reuse

Priority aspects to be covered by minimum quality requirements for water reuse in irrigation include: microbiological contaminants, monitoring, and other chemicals addressed by EU legislation, both for irrigation and groundwater recharge purposes. While these aspects are generally subject to large consensus within and across key categories of respondents (economic sectors, types of organisation), the following differences can be noted:

- Respondents from the agricultural sector are less favourable to including aspects related to monitoring, while there is strong support from most other sectors,
- Respondents from the food, drinking water and sanitation sectors are also the least inclined to identify additional chemicals as aspects as needing to be included.

Other aspects are more controversial within and across categories of respondents, such as risk-based management or the question of nutrients. Risk-based management approaches were considered by many respondents and participants as relevant to ensure adequate protection of health and the environment, but their practical implementation was subject to extensive discussions. They can be perceived as costly, time-consuming and requiring specific expertise. The question of nutrients is considered as a priority aspect to be covered when reusing water for aquifer recharge while interest for such an aspect is more moderate for irrigation purposes. There, it can be seen both as a benefit from a recycling perspective and a key barrier for ends-users like farmers, with high risks of environmental contamination (nutrient surplus and leakage to the aquifer, eutrophication). Yet, this aspect is, in both cases, of very high interest to the health sector (73% in the case of irrigation and 79% in the case of aquifer recharge). Some respondents were concerned that water reuse, if not well regulated, may contribute to pollution of aquifers and soils, although to a lesser extent.

Other uses which are out of the scope of this initiative

A large majority of respondents considers the possibility or even the need for other types of uses than irrigation and aquifer recharge to be covered by EU minimum quality requirements. The limitation of the scope is described in section 1.2.1 of the IA report.

In particular, there is a large consensus, namely half of the respondents (and in particular within the health and the environment sectors) on the possibility or need to expand EU minimum requirements beyond agricultural irrigation to the irrigation of sport fields and urban green spaces.

The idea to expand EU minimum requirements particularly to industrial uses as well as to other urban uses is slightly more debated across respondents. Twenty percent and fifteen percent (respectively) of respondents would not like these uses to be covered by EU requirements (compared to 10% for both other uses), while 40% of respondents think they should be included. Comments from some respondents on industrial uses highlighted a possible confusion with regards to the scope of the water reuse initiative for irrigation and aquifer recharge: they put forward initiatives from the industry in terms of recycling and reuse of their own waste water, while the waste water considered in this initiative must be covered by the UWWTD.

Annex 3 - Who is affected by the initiative and how

This Annex sets out how the new legal instrument would function in practice in the Member States.

As indicated in the description of the policy options, the legislative instrument will require that **any water reuse scheme is subject to a permit** delivered by competent authorities in Member States; EU minimum quality requirements will apply to those permits. It will in no case be imposed on Member States to develop or promote water reuse in their territory.

The key principles of a risk management framework would be compulsory as part of the authorisation procedures and conditions of granting permits to any water reuse project in the EU (as described in section 4.2). The key principles would cover the different steps and operators of the water reuse system (urban waste water collection and treatment, additional treatment if any, distribution, storage if any and irrigation at farm). In practice, the legal instrument would foresee that, before such a permit can be authorised, the applicant of the permit has to perform a thorough identification and assessment of risks specific to the project and its environment. Key requirements for this risk assessment would be laid down based on description of the risk management framework in Annex 7 and would cover:

- **description** of the water reuse system;
- **identification of hazards** and risk assessment, in particular:
    - additional characterisation and monitoring of pollutants in raw effluent (source control);
    - characterisation of human exposure and of the local environment vulnerability;
- **determination of preventive measures** to limit risks, e.g. including requirements on wastewater treatment, restrictions on crops and irrigation techniques, access to fields, buffer zones etc.
- **operational procedures** to ensure the system will deliver the appropriate safety, including verification of water quality and management of incidents and emergencies, need for advanced additional mitigation measures regarding treatment, access to fields, buffer zones etc.

Reflecting the outcome of the risk assessment, the permit to be delivered by competent authorities in the Member States would include additional conditions to the minimum requirements ensuring safety of agricultural products, in terms of:

- additional quality criteria (parameters and limit values) to be complied with, at the outlet of the (advanced) treatment plant or in more appropriate location in the system;
- monitoring frequencies for these quality criteria;
- additional preventive measures conditions;
- management plan and procedures to be followed when operating the water reuse system.

A water reuse scheme involves a number of operators, respectively in charge of collection and treatment of urban waste water, additional treatment for achieving the required quality for reuse (as necessary), possible storage, distribution to farms and to irrigated fields, application to crops etc. Designs of water reuse schemes are very diverse in Member States and distributions of roles and responsibilities differ widely; as a result holders of existing permits for water reuse may be any of the above operators, or any association of those.

Application of the "fit-for-purpose" approach

The legislative proposal requires different levels of quality depending on the crops and irrigation techniques. As a result, in the design of a water reuse scheme, a quality class will be targeted, and the treatment technology will be installed and operated accordingly. When this quality is lower than the most stringent one in the legislative proposal (class A) irrigation will be allowed only for certain crops and with certain irrigation techniques, as detailed in the legislation proposal. The "fit-for-purpose" requirements allow for certain flexibility in adapting the level of treatment to the actual use in irrigation:

- in farming areas where only crops with low sensitivity are grown with irrigation technique that prevent contact with edible part of the crop, a less stringent water quality will be allowed, thus saving treatment costs;

- where crops with different sensitivities are grown in different periods, the level of treatment can be adapted and changed between periods, e.g. by turning off or by-passing the most advanced disinfection treatment

- when crops with different sensitivities are grown in different areas with separated distributions systems, the level of treatment and the quality of reclaimed water can be adapted and different in the different distribution systems.

Application to existing water reuse schemes

Existing legislations in Member States already require water reuse schemes to be subject to an authorisation. Existing legislations and authorisations will need to be reviewed and possibly revised to comply with the new EU legislation. The legal instrument would set a transition period [2 years] for existing legislations and water reuse schemes to be made compliant.

As regards quality criteria, in many cases the ones imposed by existing legislations in Member States, are more comprehensive and more stringent than the ones required by the future legislative proposal. In a few cases where existing legislations and authorisations impose less stringent quality criteria, these will need revision, e.g. microbiological criteria for validation of the most stringent quality class (irrigation of crops consumed raw which edible part are in direct contact with reclaimed water) in Spain. This will impact on both the competent authorities (revision of legislation and existing permits) and holders of permits (adaptation of the level of treatment, with possible increase in treatment cost).

In many cases quality criteria in the new EU legislation will be less stringent than required by the national legislation. As the EU legislation will set only minimum requirements, Member States will not be obliged to change their legislation to align with the EU standards. However it is expected that this EU legislation will trigger discussion in Member States regarding the evidence base and relevance of national legislation. This would lead to some revision of existing national legislation, and be reflected in less costly treatment requirements.

Additionally existing authorisations in Member States are usually granted on the basis of an ex ante assessment of impacts; permit conditions are set to mitigate identified risks and impacts. This process (ex ante impact assessment and mitigation measures) fulfils to a certain extent the risk management framework required by the future legislative proposal. However in most cases part of this risk assessment will be missing, e.g. as regards accumulation of pollutants in soils. In those cases additional assessment and possibly additional conditions to the permit will be needed to comply with the new legislative instrument. Additional conditions will mostly consist of additional monitoring, and additional treatments. Depending on the decision by competent authorities in Member States this additional assessment and additional measures is likely to be at the expenses of the permit holder. As this additional risk assessment will further ascertain and quantify risks, it is expected that it will also contribute to fit existing conditions to actual risks, and in particular allow for less costly monitoring and treatment requirements.

Beyond possible specific changes to the treatment facility, it is expected that the new EU Legislation will not require any further change into the existing infrastructure, in particular as regards storage and conveyance of reclaimed water to farms, and a farm level.

Application to new water reuse schemes

Any new water reuse scheme shall be subject to a permit delivered by competent authorities in Member States and complying with the EU minimum quality requirements. This permit will be granted on the basis of a risk assessment by the applicant complying with the EU requirements. Permit conditions will include at least the minimum quality criteria of the new EU legislation and additional conditions as deemed necessary to manage the identified risks.

In Member States with no legislation in place, no new and specific legislation will be needed to regulate new projects as the EU legal instrument will provide a full-fledged legislative framework that can be directly implemented by competent authorities and applicants of permits.

In Member States where existing legislation already regulate water reuse, revision will be required within a transition period, on aspects for which the EU requirements are more stringent. For aspects where the EU legislation is less stringent, no revision will be legally required but some can be expected as result of discussion trigged by the new EU legislation.

When a new water reuse scheme is developed in an area where irrigation does not exist and/or when this project will convey water to farms or fields which were not irrigated before, investment will be necessary to develop the infrastructure downstream of the urban waste water treatment plant, both off-farm (facilities for additional water treatment, storage, distribution) and on-farm (distribution to field, irrigation material). The impact of the project is likely to increase the abstraction pressure on water resources. In those cases, it will be the responsibility of the competent authorities in Member States to check that this new / increased pressure will not impair the status of the water body, as required by the WFD, before issuing any such permit.

When a new water reuse scheme is developed to bring reclaimed water to farms which were already practicing irrigation before with individual access to water, investment will be necessary to develop an off-farm infrastructure downstream of the urban waste water treatment plant, both off-farm (facilities for additional water treatment, storage, distribution) but it is expected that on-farm equipment will not require significant additional investment. In cases where the farming area depends on a collective access to irrigation, it is expected that most of the distribution and storage infrastructure can also be used for reclaimed water; new investment will be limited to the additional treatment (if necessary) and conveyance from the urban waste treatment plant to the collective distribution system. In both cases the new water supply can be used either to substitute or to increase the volume of irrigation water. It will be the responsibility of the competent authorities in Member States to check that the project will not impair the status of the water body, as required by the WFD, before issuing any such permit. It is expected that, for most projects developed in water scarce areas, the volume of reclaimed water will result in a full or partial substitution of existing abstractions on over-exploited resources (and revision of existing abstraction permits accordingly), with a positive impact on those resources. However it could also result in the opposite impact with increased irrigation and increased negative impact on water resources, similarly to the "rebound effect" of water saving technologies which tends to increase (rather than decrease) the rate of water consumption (cf. Blueprint). The actual impact on water resources will ultimately depend on the decision of the competent authority that will have the possibility to condition the permit for a new water reuse scheme to a reduction of existing abstraction permits.

Coherence with other EU legislation

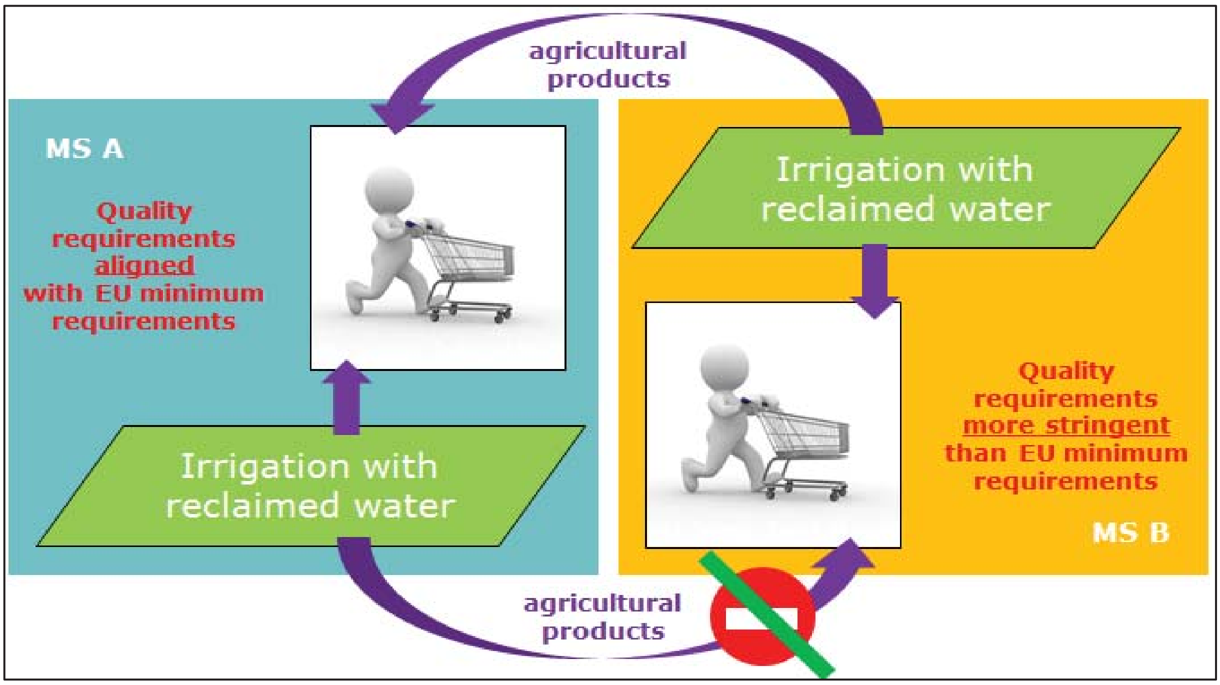
Quality requirements would complement, but not decrease, the ones laid down by the UWWTD and relevant European Case-Law[18] in particular as regards the quality of discharge effluents. When complying with the new legal instrument, reclaimed water at the outlet of the treatment plant would need to respect the criteria of the "clean water" as defined by the Regulation on the Hygiene of Foodstuffs (852/2004). Hence consistency with other relevant legislation is ensured in either approach. It is to be noted that this "clean water" definition pertains to its envisaged use in primary production and regarding the safety of foodstuffs. It does not prejudge its possible impact on water resources and ecosystems[19]. In practice the proposed legal instrument would foresee that whenever reclaimed water is used for agricultural irrigation in an EU Member State, this is subject to a permit. In any case the urban waste water treatment plant would still be subject to the application of the UWWTD, taking into account the nature of the area where the irrigation will take place, and farmers would retain the responsibility to maintain this status of clean water and of other duties laid by Regulation 852/2004 (as for any other irrigation sources). Member States competent authorities would be responsible for enforcing the permit and carrying out inspections as necessary.

As depicted in Figure 10 (see section 4.3.3 above), the legal instrument would set minimum requirements, and any Member State (Member State B in the Figure) could still adopt or retain more stringent legislation for water reuse in its territory. However, no Member State could ban imports of food products irrigated with reclaimed water in another Member State (Member State A in the Figure) enforcing the legal instrument.

Figure 10: trade of agricultural products irrigated with reclaimed water within the EU

[18] ECJ Judgement cases C-119/2002, and C-335/07

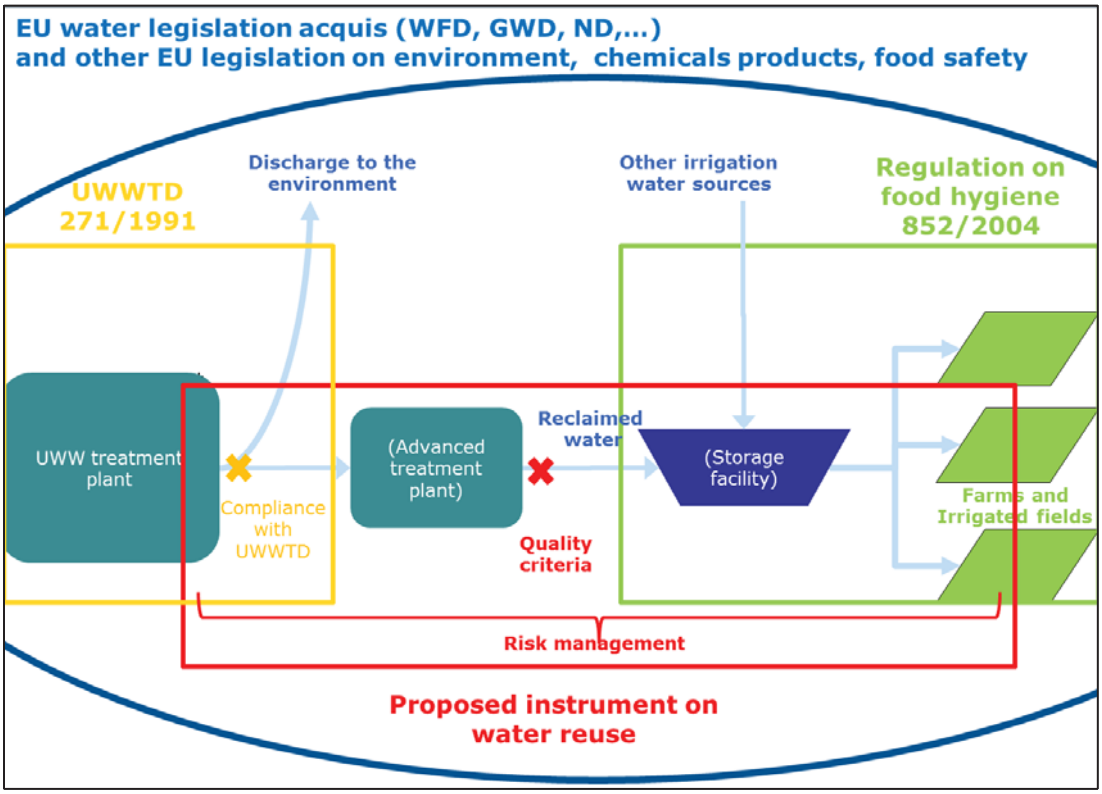
[19] E.g. nutrient content of reclaimed water is not specifically addressed in these requirements because of their safety to foodstuffs, while they may negatively affect the trophic status of receiving waters.



As illustrated by Figure 10, the proposed instrument would complement existing legislation and address specific risks in the context of water reuse projects typically composed of:

- an urban waste water treatment plant
- a possible advanced treatment plant
- infrastructure conveying reclaimed water from the (advanced) treatment plant to farms irrigated fields, possibly with intermediary storage facilities.

Figure 23: Existing EU legislation and proposed instrument for water reuse



In this system, all impacts on surface waters, ground waters and dependent ecosystems are subject to provisions of existing water law, in particular the WFD, the Groundwater Directive and the Environment Quality Standards Directive. The UWWTD also sets requirements on the collection and treatment of urban wastewater and on the quality of effluent discharged to the environment, including specific requirements for discharges into sensitive areas and/or their catchments, nutrients removal and other treatments such as disinfection. These requirements also apply to water that will be reused. Given its nutrient content, reclaimed water is to be considered as a fertilizer and its application on agricultural land is subject to the provisions of the Nitrates Directive (91/676/EEC), in particular as regards periods when the land application of fertilizers is prohibited and balanced fertilization measures, such as the inclusion in fertilizer plans and in the records of fertiliser use, and also of the UWWTD if the irrigated lands are sensitive areas or their catchments, which require nutrients removal. Detailed interpretation of these requirements is provided in the "*Guidelines on Integrating Water Reuse into Water Planning and Management in the context of the WFD*".

On the other hand, as mentioned above, the use of reclaimed water in irrigation for primary production of food products is subject to the requirements of the Regulation on the Hygiene of Foodstuffs. According to its Annex I / Part A setting hygiene provisions for primary production and associated operations:

2. As far as possible, food business operators are to ensure that primary products are protected against contamination, having regard to any processing that primary products will subsequently undergo. […]

4. Food business operators rearing, harvesting or hunting animals or producing primary products of animal origin are to take adequate measures, as appropriate:[…]

(d) to use potable water, or clean water, whenever necessary to prevent contamination; […]

Therefore as any other irrigation water source, reclaimed water for irrigation should comply with the definition of "*clean water*" at the point of use, i.e. water "*that does not contain micro-organisms, harmful substances in quantities capable of directly or indirectly affecting the health quality of food*" according to article 2 of Regulation 852/2004. This "clean water" requirement is not translated into a set of quality standards in the Regulation. Further details on implementation on grounds of this requirement are given in the Commission Notice on "Guidance document on addressing microbiological risks in fresh fruits and vegetables at primary production through good hygiene" (2017/C 163/01 of 23 May 2017).

Figure 24: Overview of benefits and costs

I. **Overview of Benefits** (total for all provisions) – Preferred Option(s)		
Description	Amount	Comments
Direct benefits		
Reduction of water stress	more than 5%, corresponding to a benefit of about EUR 3 billion/year for the whole EU assuming a willingness to pay of about EUR 0.5/m3 for preserving natural flows in rivers and aquifers.	Ir2 would enable reusing more than 50% of the total volume theoretically allocated for irrigation; the total available volume would enable a water stress reduction of ca.10%, Ir2 would enable a reduction of more than 5% (see section 5.2.1)
Reduction of nutrient pollution	more than 5% of agricultural mineral fertilizers	Ir2 would enable reusing more than 50% of the total volume that can be theoretically allocated for irrigation; as the total volume would enable reducing the use of mineral fertilizers in agriculture by about 10%, Ir2 would enable a reduction of more than 5% (see section 5.2.1)
Indirect benefits		
Increased reliability of water supply for agricultural irrigation and therefore more sustainable production of agricultural products.	Not quantified at EU scale, but in the order of 1 billion/drought year. In the Po plain, Italy, costs were quantified inEUR 500-1000 million during a drought year.[20]	Reuse would enable farmers to depend less on freshwater resources, whose use may be more severely restricted during droughts.

II. **Overview of costs** – Preferred option(s)						
	Citizens/consumers		Businesses		Administrations	
	One-off	Recurrent	One-off	Recurrent	One-off	Recurrent

[20] In a paper on the Po plain in Italy, Musolino et al. (2017) quantify an impact of droughts on the overall welfare (farmers+consumers) in the order of EUR 500-1000 million/year during droughts. The affected population is more than 16 million persons. This may suggest a cost of about 30-60 Euro/person during drought years and is in fact in line with the figures on the willingness to pay provided above. The authors stress that farmers alone benefitted from drought as the price increase was stronger than the production loss in the area. As reuse contributes to water stress reduction in the order of 10%, we may assume an indirect benefit of 50-100 million Euro during drought years, for the Po plain alone. Considering a drought that simultaneously affects an area 10 times as big as the Po plain in Europe, the indirect benefits for the whole of Europe would go back to 500-1000 million Euro during a drought year. Source: Dario Musolino, Alessandro de Carli, Antonio Massarutto, Evaluation of the socioeconomic impacts of the drought events: The case of the po river basin. Europ. Countrys. · 1 · 2017 · p. 163-176 DOI: 10.1515/euco-2017-0010.

Water reuse development[21]	Direct costs	-	Top-up of farmers' payment for reused water: EUR 0.25 /m3	Investment for reuse system infrastructure (treatment+ transport): EUR 700 million[22]	Farmers' payment for reused water EUR 0.25 /m3; Monitoring by the reclaimed water provider[23]		Monitoring results review, inspections
	Indirect costs						
Risk assessment[24]	Direct costs			Studies to support risk quantification		Administra tive procedure for risk assessment technical work for risk quanti fication review	
	Indirect costs						Managing public access to information

[21] For the sake of this Impact Assessment, and without prejudice for future specific assessments in other contexts, the calculations assume a total levelized cost of reused water of EUR 0.5 /m3, of which approximately 50% is paid by the farmer and 50% by the citizens in exchange of the corresponding environmental benefits.
[22] These costs are part of the estimated recurrent costs.
[23] The total costs of water reuse are assumed to correspond to 0.5 Eur/m3. In principle, these costs should be covered by the water user, but in many cases there may be a more general interest in water reuse because of the broad benefits it may bring for water stress reduction. Consequently, it is possible that part of the costs be subsidized through taxpayers' money or passed on to consumers through increases in prices. In this table, exclusively for the sake of providing a first quantification, we assume that the cost of reused water be equally shared between farmers and taxpayers (or consumers), 0.25 Eur/m3 each
[24] Costs not quantified

Annex 3a –SME test

(1) Preliminary assessment of businesses likely to be affected
A total of roughly 11 million farms operated in the EU-28 in 2013. All the farms of the European Union are micro or small following the definition of the EU enterprises. Very few farms are small and the wide majority are micro enterprises[25]. The total number of jobs in agriculture is 8.7 million jobs in terms of Annual Working Units (AWU) when in irrigated farms is 20% according to Eurostat. The production value is 26% in irrigated farms on the total Standard Output. The number of irrigated farms is in total 1.7 million, 16% of total farms. In 2013 the total irrigated area in the EU was 10.2 million hectares, accounting for 5.9% of the total Utilised Agricultural Area (UAA). Southern European countries like Spain, France, Italy, Greece and Portugal show the highest amounts of irrigated land. Indeed, in Southern Europe agriculture accounts for more than 50% of water abstractions: Spain (60%), Greece (88%). Together, these countries account for 86% of the total. On the other side, in Denmark and the Netherlands irrigated UAA makes up less than 3% of the total UAA.
(2) Consultation with micro and small enterprises representatives
The farmers' association at EU level (COPA-COGECA) was overall appreciative of the concept, stating that it will contribute to a more resilient farming sector, help overcome pressures deriving from climate change and, in upcoming years, be not only an alternative supply option but rather the most important source of clean water. Challenges highlighted were the need to identify the right quality of water, whereby the minimum quality requirements must take into account specific local needs and give flexibilities to the regions and Member States. Reclaimed water for irrigation should be nutrient-free as well as particle-free. Affordability of the proposed water reuse schemes should be carefully considered. COPA-COGECA further indicated that the compliance should be at the point where reclaimed water is discharged by the treatment plant. Finally, any new instrument should be light and not inflict administrative burden. It should only apply to those practicing reuse.
(3) Measurement of the impact on SMEs
Farmers are affected in proportion to the volume used of reclaimed water and therefore micro enterprises are not affected differently than bigger farms. Moreover, it is by crop type grown that requirements in stringency differ, for instance for so called energy crops the minimum requirements are much lower than for fruit and vegetables. Therefore fruit and vegetable growers are more significantly affected in case they irrigate with reclaimed water than farmers growing energy crops.

[25] http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en

As regards water costs for irrigation paid by farmers in 2013, on the basis of FADN (Farm Accountancy Data Network) for agriculture, the ratio of water costs for irrigation on total intermediate consumption (specific costs and farming overheads), the situation by Member State is the following:

MS	In % 2013	MS	In % 2013
Belgium	0,32	Lithuania	0,44
Bulgaria	0,70	Luxembourg	2,13
Cyprus	2,72	Latvia	0,08
Czech Republic	0,46	Malta	0,71
Denmark	0,32	Netherlands	0,24
Germany	0,71	Austria	0,24
Greece	3,08	Poland	0,51
Spain	4,42	Portugal	0,27
Estonia	0,07	Romania	0,99
France	0,94	Finland	0,42
Croatia	1,11	Sweden	0,25
Hungary	0,51	Slovakia	0,26
Ireland	0,48	Slovenia	0,94
Italy	1,53	United Kingdom	0,79

The incidence of costs for irrigation is generally low in comparison with the total intermediate consumption. It appears to be more important in Spain, Greece, Cyprus, Italy, Luxembourg and Croatia. In Spain the incidence of water cost on the output per group of crops is measured at 4.1% for field crops, 4.2% for horticulture and 4.9% for permanent crops. The same indicator amounts to 1.2% on field crops, 0.3% for horticulture, 0.9% for permanent crops in Italy, while in Greece the water costs paid compared to output are at 2.7% for field crops, 1.5% for horticulture and 1.9% for permanent crops.

However these prices paid for water do not reflect the real water costs of irrigation as often these prices are subsidised and are therefore borne by society and the environment.

The impact assessment calculates the amount of reclaimed water which could be made available to farmers at the cost of 0.5 €/m3. In water scarce areas 0.5 €/m3 is a competitive price given the fact that prices for conventional water are in the same order of magnitude in areas of severe water stress and would not raise irrigation costs significantly compared to total intermediate consumption. For instance according to Custodio (2015) common prices for groundwater in Spain range between 0.3 and 0.5 €/m3 (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 €/m3 though during peak demand they can go beyond 1 €/m3. Existing irrigation freshwater tariffs range significantly across Greece (0.02-0.70 €/m3)[26]. (For more information please see in Annex 4 the sections for some selected MS.)

Moreover estimations of the Commission show that by 2030 important spring and summer droughts are expected in Southern and Centre of Europe to a degree that competition among sectors for water is expected to raise water prices. Under these conditions reclaimed water becomes progressively more competitive compared to other water sources used for irrigation.

Reclaimed water can be of major interest for farmers when urgent irrigation interventions in water stress conditions for crops is necessary (e.g. the case of summer 2017 when some of the crops' production was lost due to drought). Farmers could be interested to pay a higher price to save crops at risk of total or partial loss. Moreover farmers can benefit from a secure water supply if relying on reclaimed water for irrigation purposes, compared to the risk of unavailability of freshwater for irrigation purposes in case of water bans in water scarce areas in periods of severe water shortages. Increased reliability of water supply for agricultural irrigation and therefore more sustainable production of agricultural products could add up to benefits of EUR 500-1000 million during a drought year. Under these circumstances the cost of reclaimed water would be offset by these indirect benefits[27]. While this estimation is very rough, it at least shows that, in areas where droughts are (or are likely to become) common, water reuse is clearly also beneficial from an economic point of view.

Therefore farmers are motivated to substitute freshwater sources with reused water in areas with water stress, so areas where freshwater and other sources of water become unavailable (e.g. droughts and potentially resulting bans to use the available water for irrigation purposes) or too costly (e.g. increasing energy costs for pumping of the groundwater due to lowering of groundwater levels).

Willingness to pay for reused water will differ across regions depending on differences in water stress, availability of other conventional water sources and their price. Studies on

[26] (Pinios case study, Annex 4)

[27] In a paper on the Po plain in Italy, Musolino et al. (2017) quantify an impact of droughts on the overall welfare (farmers+consumers) in the order of EUR 500-1000 million/year during droughts. The affected population is more than 16 million persons. This may suggest a cost of about 30-60 Euro/person during drought years and is in fact in line with the figures on the willingness to pay provided **in Annex 4**. The authors stress that farmers alone benefitted from drought as the price increase was stronger than the production loss in the area. As reuse contributes to water stress reduction in the order of 10%, we may assume an indirect benefit of 50-100 million Euro during drought years, for the Po plain alone. Considering a drought that simultaneously affects an area 10 times as big as the Po plain in Europe, the indirect benefits for the whole of Europe would go back to 500-1000 million Euro during a drought year. Source: Dario Musolino, Alessandro de Carli, Antonio Massarutto, Evaluation of the socioeconomic impacts of the drought events: The case of the po river basin. Europ. Countrys. · 1 · 2017 · p. 163-176 DOI: 10.1515/euco-2017-0010.

willingness to pay (see Annex 4 for more details) show that willingness to pay is extremely variable (for instance, Birol et al., 2007[28] estimate a willingness to pay higher than EUR 0.6 /m^3 in Cyprus, while Tziakis et al., 2009[29], indicate less than EUR 0.1/m3 for Crete), see Annex 4 for further details on the range of different studies and estimations for the value of 1 m^3 of water. These examples in the Annex highlight the large variability in valuation of water used to reduce water stress, and the uncertainty due to their high case-specificity. In this assessment, we adopt a benefit of water reuse of EUR 0.5 /m^3, which is in the mid-lower end of the cases examined above, and may be argued to represent as a first approximation of the combined market and non-market value of water reuse in Europe, provided it contributes to reducing water stress. Therefore it can be concluded that in areas of high water stress it is a reasonable assumption that there would be an overall willingness to pay by farmers and society for the set 0,5 €/m^3 cost of reclaimed water, for which this impact assessment calculates the uptake of water reuse at this given cost.
4) Assess alternative options and mitigating measures
There are no mitigating measures necessary given the fact that micro enterprises and SMEs are not disproportionately affected.

[28] Birol, E., P. Koundouri, and Y. Kountouris (2007), Farmers' demand for recycled water in Cyprus: A contingent valuation approach, in Wastewater Reuse—Risk Assessment, Decision-Making and Environmental Security, edited by M. K. Zaidi, pp. 267–278, Springer, Dordrecht, Netherlands.

[29] Tziakis, I., I. Pachiadakis, M. Moraittakis, K. Xideas, G. Theologis and K. P. Tsagarakis (2009), Valuing benefits from wastewater treatment and reuse using contingent valuation methodology, Desalination, 237, 117–125.

Annex 4 - Analytical models used in preparing the impact assessment

This annex provides a description of the models used for certain aspects of this impact assessment:

- The model developer and nature (public/private/open source) of the model;
- Model structure and modelling approach with any key assumptions, limitations and simplifications;
- Intended field of application and appropriateness for the specific impact assessment study presented;
- Model validation and peer review with relevant references;
- The extent to which the content of the model and input data have been discussed with external experts;
- Explanation of the likely uncertainty in the model results and the likely robustness of model results to changes in underlying assumptions or data inputs;
- Explanation as to how uncertainty has been addressed or minimised in the modelling exercise with respect to the policy conclusions; and
- The steps taken to assure the quality of the modelling results presented in the IA.

We make use of a hydro-economic model to estimate the demand of water for irrigation, and the costs of treating and deploying reclaimed water to agricultural land within a distance of 10 km from existing wastewater treatment plants. On this basis, we conduct the analysis of volumes and costs of reclaimed water under the two policy options "one size fits all" (Ir1) and "fit for purpose" (Ir2) considered in the Impact Assessment.

The key elements of the models are summarized in Table 1. In the following, we first introduce the models in more details, and then describe the main assumptions and sources of data used for the assessment. The material presented here is based on Pistocchi et al., 2018[30].

In addition to describing the models used in this assessment, we provide details on (1) the quantification of the benefits from water reuse; and (2) the calculation of the administrative burden of the proposed instrument.

General aspects of the models used in the Impact assessment

The key assumptions and data sources are described in this Annex. The assessment refers to a conventional baseline where reuse is a negligible source of water for irrigation in Europe in the absence of specific policies, because of the lack of a clear legal framework enabling steady investment in this area. For the rest, we assume the water legislation (and particularly the Urban Wastewater Treatment Directive) to be correctly implemented across Europe.

The most critical aspect of the assessment is the evaluation of costs of reclaimed water. The cost of wastewater reuse is computed as the sum of the cost of: 1) treatment of water for reuse; 2) building infrastructures for water storage and distribution (pipelines and pumps); and 3) energy for reclaimed water pumping from the wastewater treatment plant to the neighboring agricultural areas (Figure 1).

[30] Pistocchi, A., Aloe, A., Dorati, C., Alcalde Sanz, L., Bouraoui, F., Gawlik, B., Grizzetti, B., Pastori, M., Vigiak, O., The potential of water reuse for agricultural irrigation in the EU. A Hydro-Economic Analysis, EUR 28980 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-77210-8, doi 10.2760/263713

Figure 1 – scheme of the costs considered in this assessment.

Although both investment and operation costs of water reuse are highly dependent on conditions such as the level of treatment already existing at a plant and the size of the plant, mean levelized treatment costs[31] are pragmatically assumed to be constant across Europe. This assumption still enables analyzing the difference of the two policy options considered in the Impact Assessment, without the need for a representation of the variability of wastewater treatment plant conditions at European scale. Such representation would be anyway rather challenging to develop, due to the extreme sensitivity of investment and operation costs to local conditions. At the same time, while variable, the impact of treatment cost variability is attenuated by the variability of water transport costs that is, on the contrary, more predictable as it depends on distance, elevation differences and other relatively simple parameters (as also shown in the global sensitivity analysis exercise reported below). Therefore, in this assessment we refer to the mid-range of treatment costs provided by Iglesias et al., 2010. We assume option Ir2 to correspond to an intermediate treatment requirement corresponding to disinfection and depth filtration, and Ir1 to an advanced treatment with membrane filtration and disinfection.

In order to evaluate the potential of reusing reclaimed water, we estimate the cost of treatment and the cost of transport of water, which requires defining a source and a destination of reclaimed water in order to quantify a transport distance and an elevation difference for pumping. We assume that water sources coincide with wastewater treatment plants as depicted in the WaterBase – Wastewater v. 4.0 dataset made available at the European Environment Agency[32]. Moreover, we distribute in space the estimated irrigation demand assuming that all agricultural land excluding pastures is potentially irrigated, thus neglecting the actual distribution of irrigation infrastructure. We conduct appropriately aggregated calculations using the elementary sub-basins of the CCM2 database[33] as a mapping unit, without disaggregating results therein. A major source of uncertainty is represented by the spatial scale and resolution of the analysis. The assumptions made and the data used as input do not enable any conclusion on specific situations, but suggest only general trends valid at European scale. All conclusions of this assessment must be considered indicative at a broad strategic level, and can by no means serve the purposes of case-specific assessments. Particularly, the assessment cannot be regarded as a pointwise evaluation of the potential of a specific wastewater treatment plant, but as yielding representative frequency distributions of

[31] In analogy with the case of energy, the levelized cost is the net present value of the unit-cost of water over the lifetime of a generating asset.
[32] https://www.eea.europa.eu/data-and-maps/data/waterbase-uwwtd-urban-waste-water-treatment-directive-4
[33] http://inspire-geoportal.ec.europa.eu/demos/ccm/

costs at a regional scale, such as EU NUTS2 level or river basins. Results are consistently presented at resolutions not finer than these.

The results of the EPIC model, while uncertain, have less critical implications for the conclusions of the study and were not subjected to specific uncertainty analysis. Their uncertainties are discussed on a qualitative basis, when necessary, in the specific sections of this document. EPIC has been calibrated using data publicly available from EUROSTAT and EEA.

This assessment is based on the current wastewater treatment plant system in the EU, as well as on current estimated irrigation requirements and fertilizer use. We do not make assumptions on other macroeconomic, socio-economic conditions nor policies and measures, as the scope is limited to quantifying a possible cost distribution for reuse of wastewater. Information on wastewater treatment plants in Europe is derived from the European Environment Agency's Waterbase dataset, v. 4. Additional details on models, data, and the estimation of water quantity and quality at wastewater treatment plants are given in a JRC report accompanying this Impact Assessment.

Model and model type	**Developer**	**Intended field of application/appropriateness**	**Validation and peer review**	**Discussed with external experts**	**Quality control and uncertainty**
EPIC agronomic model	USDA (open source)	Simulation of crop yields, nutrient and water requirements; appropriate for irrigation demand estimation and the corresponding yields	Illustrated in this annex	EPIC model included in JRC Blueprint study. No specific discussion.	Illustrated in this annex
Hydro-economic model	JRC	Calculation of costs of water treatment and distribution; appropriate to extend simple cost calculations to the various contexts in Europe based on the spatial relationships of wastewater treatment plants and agriculture	FEASIBLE model equations endorsed by OECD. No specific validation.	FEASIBLE model used for other EC studies. No specific discussion.	Informal checks on compatibility of the results of equations with common experience; global sensitivity analysis

Table 1 – models used in the assessment

Hydro-economic model

The equations used for the assessment of costs were developed specifically for the present assessment, following engineering assumptions widely adopted in practice, and are presented in a specific section of this report. The cost appraisal equations used for the assessment derive from the literature, and particularly from the FEASIBLE model (OECD, 2004) for what concerns the cost of pipelines and pumping stations these were already used in previous assessments at the European Commission (e.g. European Commission, 2010); for the costs of storage, we follow the assumptions made in Maton et al., 2010.

For the cost calculations, apart from the sensitivity analysis conducted on purpose to address uncertainties, comparisons have been drawn with costs reported from experts referring to real cases in Europe or comparable contexts. For the purposes of this assessment, we assume the costs indicated by Iglesias et al., 2010, to be representative of the whole European context. It must be stressed that the costs considered here are additional to those required anyway to comply with the legislation on urban wastewater treatment.

For policy option Ir2 ("fit-for-purpose"), we assume treatment costs for a reference condition where effluent standards for reclaimed water can be obtained by a treatment consisting of depth filtration and disinfection, for which Iglesias et al., 2010, report a mean investment cost in the range of 28-48 €/(m3/day) and an operation cost in the range 0.06-0.09 €/m3. Under option Ir2, in fact, it is possible that water is reused with lower treatment costs as well as higher treatment costs (the latter only for the share of water volumes requiring the highest standards). As it is currently impossible to assume how much of the water volume available for reuse will be treated at which level of quality, adopting a lower-middle level of treatment costs appears a reasonable pragmatic assumption. The range of levelized costs of treatment (LCOWt) is computed assuming a discount rate of 5% and a depreciation period of 20 years, as:

$$LCOWt = (LCOW_{t,\ min} + LCOW_{t,\ max})/2$$

with

$$LCOW_{t,\ min} = 0.06 + 28 / pva(0.05, 20)/365$$

$$LCOW_{t,\ max} = 0.09 + 48 / pva(0.05, 20)/365$$

and with pva(r, n), representing the present value of investment cost annuity, defined in Equation 15 below. For policy option Ir1, we consider that membrane filtration and disinfection are required to achieve the quality standards. For this case, Iglesias et al., 2010, provide a mean investment cost in the range of 185-398 €/(m3/day) and an operation cost in the range 0.14-0.20 €/m3. We compute the levelized costs of treatment as:

$$LCOW_{t,\ min} = 0.14 + 185 / pva(0.05, 20)/365$$

$$LCOW_{t,\ max} = 0.20 + 398 / pva(0.05, 20)/365$$

Table 7 summarizes the adopted levelized costs.

Option	LCOWt cost (min)	LCOWt(max)	LCOWt
Ir1	€ 0.18	€ 0.29	€ 0.23
Ir2	€ 0.07	€ 0.10	€ 0.08

Table 7 – water treatment costs assumed for the two policy options

The treatment costs are the only difference between the two policy options considered in this assessment. On the contrary, it is assumed that the infrastructure to distribute reclaimed water from wastewater treatment plants does not presently exist and needs to be developed.

The model adopted to calculate the cost of water distribution refers to the spatial support represented by the sub-basins of the CCM2 dataset[34]. Table 8 summarizes the attributes of sub-basins considered for model calculations.

Symbol	Description	Source
i	Sub-basin identifier	-
($x_{p,i}$, $y_{p,i}$, $z_{p,i}$)	Coordinates of the center of mass of WWTPs present in the SB	Computed with Equation 1 using the capacity of WWTPs (PE) as masses; coincides with WWTP coordinates if only one WWPT is present
(x_i, y_i, z_i)	Coordinates of the center of mass of agricultural areas present in the SB	Computed with Equation 2. Agricultural areas are all pixels in CLC2012 with level 1 code=2, excluding level 3 code 231 (pastures)
A_i	Extent of agricultural area in the SB	See above
R_i	Radius of inertia (dispersion) of the agricultural area in the SB	Computed with Equation 3. See above
φ_i	Porosity (share of the SB accessible for pipelines)	Computed with Equation 4 using Open Street Map roads layer, agricultural land (including pastures) and slope from SRTM 100 m DEM
τ_i	Tortuosity	Computed from porosity using Equation 5
Q_i	output discharge of the WWTPs present in the SB	From EEA UWWTP database v.4 as revised by Vigiak et al., 2017
α_i	fraction of discharge Q_i that is reclaimed	Set to default of 1
LCOWt	Cost of water treatment at the WWTPs present in the SB	See § 6.2
I_i	irrigation demand in the SB	Estimated from EPIC under the "baseline" scenario, and from EPIC results with Equation 28 under the "potential" scenario
T_i	Duration of the irrigation period in the SB	Set to a default value of 4 months (120 days).
ψ_i	Cost of energy in the SB	Set to default of 0.10 €/kWh

Table 8 – summary of attributes of each sub-basin used in the calculation (SB=sub-basin)

For the generic i-th sub-basin, we define an equivalent WWTP with coordinates of the centre of mass of all WWTPs in the sub-basin, computed as:

$$x_{p,i}=\frac{\sum_{k=1}^{m_i} P_k \xi_{pk}}{\sum_{k=1}^{m_i} P_k}$$
$$y_{p,i}=\frac{\sum_{k=1}^{m_i} P_k \eta_{pk}}{\sum_{k=1}^{m_i} P_k} \qquad \textit{Equation 1}$$
$$z_{p,i}=\frac{\sum_{k=1}^{m_i} P_k \zeta_{pk}}{\sum_{k=1}^{m_i} P_k}$$

where m_i is the number of WWPs in the i-th sub-basin, P_k the capacity (PE) of the k-th WWTP in the sub-basin, and $(\xi_{pk}, \eta_{pk}, \zeta_{pk})$ its coordinates along the horizontal axes and elevation, respectively. We define an equivalent agricultural area in the sub-basin, with an extent equal to the total agricultural area A_i within the sub-basin, with coordinates of the centre of mass computed as

$$x_i=\frac{\sum_{k=1}^{n_i} \xi_k}{n_i} \qquad \textit{Equation 2}$$

[34] http://inspire-geoportal.ec.europa.eu/demos/ccm/

$$y_i=\frac{\sum_{k=1}^{n_i}\eta_k}{n_i}$$

$$z_i=\frac{\sum_{k=1}^{n_i}\zeta_k}{n_i}$$

where n_i is the number of agricultural pixels in the i-th sub-basin, and (ξ_k, η_k, ζ_k) the coordinates of the k-th pixel along the horizontal axes and elevation, respectively. The dispersion of agricultural pixels around their center of mass is represented by the radius of inertia computed as:

$$R_i = \frac{\sum_{k=1}^{n_i}\sqrt{(\xi_k-x_i)^2+(\eta_k-y_i)^2+(\zeta_k-z_i)^2}}{n_i}$$ *Equation 3*

Each sub-basin is characterized by a porosity, meant as the share of its area where water can be in principle transported through pipelines. The latter is assumed to coincide with the ensemble of:

- A buffer of 100 m around all road infrastructure
- Agricultural land with terrain slope below 35°.

Porosity is defined as:

$$\varphi_i = \frac{accessible\ area\ in\ sub-basin\ i}{total\ area\ in\ sub-basin\ i}.$$ *Equation 4*

In the analysis of costs of water reuse, we compute the length of pipelines assuming a Euclidean distance, hence a homogeneously accessible sub-basin, while in reality the actual length will tend to be higher depending on the tortuosity of its trail. We quantify the tortuosity using the theoretical model of Bruggeman (1935; see also Tjaden et al., 2016) for two-dimensional porosity:

$$\tau_i = \left(\frac{1}{\varphi_i{}^a}\right)$$ *Equation 5*

Where a is a parameter depending on the geometry of the pores. For a space filled by cylinders, a=1 while, for a space filled by spheres, a=0.5. The higher a, the higher the tortuosity for a given porosity. In practice, a needs to be fitted to the specific case. In this exercise, we set a=0.5 by default. Moreover, we do not allow τ_i to exceed the value of 3.

Water potentially reclaimed at a given wastewater treatment plant may be transported for reuse within the plant's sub-basin (i.e. "at the source"), or towards other "receptor" sub-basins. In this exercise, we assume that water cannot be conveniently transported to sub-basins more than 10 km away (on a straight line) nor to sub-basins with elevation differences representing an excessive pumping requirement. For the latter, we assume that sub-basins featuring an elevation range above 200 m would require excessive pumping efforts and we regard them as "inaccessible". We exclude from this set those sub-basins corresponding to the valleys of relatively large rivers (those with Strahler order > 4 in the CCM2 database), where it is assumed that the valley bottoms may still host infrastructure despite the potentially high elevation ranges on the hillsides.

Within a "source" sub-basin, the flow of reclaimed water to agriculture (m3/day) is computed as:

$$F_{i,i} = \min(\alpha_i Q_i, I_i)$$ *Equation 6*

where Q_i (m3/day) is the output discharge of the WWTP, α_i (-) is the fraction of this discharge that is reclaimed (by default, α_i=1), and I_i (m3/day) is the irrigation demand in the sub-basin.

The length of the pipeline required to transport this flow to the agricultural area in the sub-basin is given by:

$$L_{i,i} = \sqrt{\left(x_i - x_{p,i}\right)^2 + \left(y_i - y_{p,i}\right)^2 + \left(z_i - z_{p,i}\right)^2}$$ *Equation 7*

while the diameter of the pipeline (m) is computed using the Hazen-Williams formula as:

$$D_{i,i} = \left(\frac{10.675 \, (\frac{F_{i,i}}{C})^{1.852}}{J} \right)^{\frac{1}{4.8704}}$$ *Equation 8*

where J is the friction loss rate and C is a friction coefficient. We assume C=120 (-), valid for steel pipes, and J=0.005 (-). Under these assumptions, with $F_{i,i}$ in m3/day, Equation 8 can be written as:

$$D_{i,i} = 0.0104 F_{i,i}^{0.3803}$$

In addition to the transport of reclaimed water to the agricultural area, we account for the distribution of this water within the agricultural area itself. The radius of inertia R_i represents the average distance of agricultural areas from their centre of mass. We assume the investment in the infrastructure for distribution to the farms to be independent of the water reuse investment, while we compute the energy cost of distributing the reused water within the agricultural area of a sub-basin, as this contributes directly to the levelized cost of water.

The expenditure for a pipeline with diameter Δ is given in €/m by[35]:

$$E(\Delta) = \begin{cases} 0.088433 \, \Delta^{1.29} + 65.8 \; if \; \Delta \leq 0.8 \, m \\ 0.0040115 \, \Delta^{1.785} + 68.1 \; if \; \Delta > 0.8 \, m \end{cases}$$ *Equation 9*

as from the FEASIBLE model (OECD, 2004). This expenditure function is used to compute $E\left(D_{i,i}\right)$.

[35] The functions are provided by OECD (2004) in US$/m. In 2004, the exchange rate of € against US $ was about 0.83. However, given the indicative value of the functions and the relative stability of the prices, we assume a unit exchange rate. This applies to all expenditure functions from the FEASIBLE model when values are given in US$.

The energy required to transport and distribute the reclaimed water within the sub-basin (kWh/year) is computed as:

$$\Psi_{i,i} = \frac{F_{i,i}}{86400\eta}(365 * 24)g\big(\max(0, z_i - z_{p,i}) + J(\tau_i L_{i,i} + R_i)\big) \quad \textit{Equation 10}$$

where g is the acceleration of gravity (9.81 m/s2) and η is the efficiency of pumping. We assume η=0.75. The power installation requirement (kW) of an equivalent pumping station for the transport and distribution of the reclaimed water flow is:

$$S_{i,i} = \frac{365\ \Psi_{i,i}}{(365 * 24)T_i} \quad \textit{Equation 11}$$

where T_i (days) is the duration of the irrigation period in the sub-basin. The expenditure for a pumping station of power S (€) is computed from the FEASIBLE model as:

$$E'(S) = 33140\ S^{0.559} \quad \textit{Equation 12}$$

The storage volume required for use of water in irrigation is computed as:

$$W_{i,i}=365F_{i,i}\left(1-\frac{T_i}{365}\right) \quad \textit{Equation 13}$$

The cost of the storage volume is:

$$E(W_{i,i})=\omega_i W_i \quad \textit{Equation 14}$$

with □$_i$ set to default of 5 €/m3 in line with Maton et al., 2010. Cost of storage is extremely variable. For natural storage (e.g. in floodplains), *Grygoruk et al., 2013 report a value above 8 €/m3.*

The expenditure for an investment can be converted into an equivalent annual cost by the "present value of annuity" factor:

$$pva(r,n) = \frac{1-\left(\frac{1}{1+r}\right)^n}{r} \quad \textit{Equation 15}$$

where r is the annual interest rate and n is the number of years of useful life (or depreciation period) of the investment. We assume n=50 years for pipelines and storage, and n=15 for pumping stations, while r=0.05 (5%).

The total equivalent annual cost of water transport and distribution (€/year) is given by:

$$E_{i,i} = \frac{E(D_{i,i})\tau_i L_{i,i} + E(W_{i,i})}{pva(0.05,50)} + \frac{E'(S_{i,i})}{pva(0.05,15)} + \psi_i \Psi_{i,i} \quad \textit{Equation 16}$$

Where ψ_i is the cost of energy (€/kWh) in the sub-basin. In this exercise, we assume a constant value ψ_i =0.10 €/kWh. The cost of energy for industrial use reported by EUROSTAT is provided in Table 9, suggesting the assumed value to be plausible for large industrial users across Europe.

Country	Consumption (MWh/year)						
	20	500	2000	20000	70000	150000	>150000
Belgium	€ 0.18	€ 0.15	€ 0.11	€ 0.10	€ 0.08	€ 0.07	€ 0.06
Bulgaria	€ 0.10	€ 0.10	€ 0.08	€ 0.07	€ 0.06	€ 0.06	€ 0.06
Czech Republic	€ 0.16	€ 0.12	€ 0.08	€ 0.07	€ 0.07	€ 0.07	
Denmark	€ 0.18	€ 0.10	€ 0.09	€ 0.09	€ 0.08	€ 0.08	
Germany	€ 0.22	€ 0.18	€ 0.15	€ 0.13	€ 0.11	€ 0.10	
Estonia	€ 0.11	€ 0.10	€ 0.09	€ 0.08	€ 0.07	€ 0.07	
Ireland	€ 0.20	€ 0.16	€ 0.13	€ 0.11	€ 0.09	€ 0.09	
Greece	€ 0.21	€ 0.17	€ 0.12	€ 0.10	€ 0.08	€ 0.05	
Spain	€ 0.27	€ 0.15	€ 0.11	€ 0.10	€ 0.08	€ 0.07	€ 0.06
France	€ 0.15	€ 0.12	€ 0.10	€ 0.08	€ 0.07	€ 0.06	
Croatia	€ 0.13	€ 0.11	€ 0.09	€ 0.08	€ 0.06	€ 0.06	
Italy	€ 0.27	€ 0.19	€ 0.16	€ 0.15	€ 0.13	€ 0.10	€ 0.08
Cyprus	€ 0.18	€ 0.17	€ 0.15	€ 0.13	€ 0.13	€ 0.12	
Latvia	€ 0.16	€ 0.13	€ 0.12	€ 0.11	€ 0.10	€ 0.09	
Lithuania	€ 0.13	€ 0.11	€ 0.10	€ 0.10	€ 0.09	€ 0.08	
Luxembourg	€ 0.17	€ 0.11	€ 0.09	€ 0.06	€ 0.05		
Hungary	€ 0.11	€ 0.10	€ 0.09	€ 0.08	€ 0.08	€ 0.08	€ 0.08
Malta	€ 0.22	€ 0.17	€ 0.16	€ 0.14	€ 0.12	€ 0.11	
Netherlands	€ 0.16	€ 0.12	€ 0.09	€ 0.08	€ 0.07	€ 0.07	€ 0.06
Austria	€ 0.16	€ 0.13	€ 0.10	€ 0.09	€ 0.08	€ 0.07	€ 0.06
Poland	€ 0.15	€ 0.11	€ 0.08	€ 0.07	€ 0.07	€ 0.06	€ 0.06
Portugal	€ 0.19	€ 0.15	€ 0.12	€ 0.10	€ 0.09	€ 0.08	
Romania	€ 0.11	€ 0.10	€ 0.08	€ 0.07	€ 0.06	€ 0.06	
Slovenia	€ 0.14	€ 0.10	€ 0.08	€ 0.07	€ 0.07	€ 0.06	
Slovakia	€ 0.20	€ 0.14	€ 0.11	€ 0.10	€ 0.09	€ 0.09	€ 0.07
Finland	€ 0.09	€ 0.08	€ 0.07	€ 0.07	€ 0.05	€ 0.05	
Sweden	€ 0.14	€ 0.07	€ 0.06	€ 0.06	€ 0.05	€ 0.04	
United Kingdom	€ 0.17	€ 0.15	€ 0.14	€ 0.13	€ 0.12	€ 0.12	€ 0.12

Table 9 – Electricity prices per kWh, for industrial consumers, excluding VAT and other recoverable taxes and levies – average of bi-annual data 2014-16 (source: EUROSTAT)

The levelized cost of reclaimed water within the sub-basin (€/m3) is:

$$LCoW_{i,i} = \frac{E_{i,i}}{365F_{i,i}} + LCOWt$$ *Equation 17*

The flow of reclaimed water potentially supplied from the i-th source sub-basin to the j-th receptor sub-basin (m3/day) is computed in a similar way. First of all, the shortest path connecting the i-th source to the j-the receptor is identified. If a receptor is not adjacent to the source but there are one or more sub-basins in between, the path is forced to pass through the center of mass of agriculture in each of these sub-basins. When a sub-basin does not contain agriculture, its centroid is considered instead. Each receptor sub-basin can be therefore characterized with the shortest path length to reach it from the i-th source (L_{ij}), and in addition with the shortest path length to reach its neighbor immediately closer to the source ($\Lambda_{i,j}$). The shortest-path lengths between two generic nodes are computed as the Euclidean distances, multiplied by the tortuosity factor of the origin node. On a par, each receptor sub-basin can be characterized by the potential flow from the i-th source basin:

$$F_{i,j} = \min\left(\max\left(0, -\alpha_i Q_i F_{i,i}\right), \max\left(0, I_j - F_{j,j}\right)\right). \quad \textit{Equation 18}$$

as well as the flow to its neighbor immediately closer to the source, which we denote as $\Phi_{i,j}$. The pipeline connecting the i-th source to the j-th receptor requires a diameter to convey $F_{i,j}$ for the length $L_{i,j} - \Lambda_{i,j}$. In addition it needs the infrastructure, already sized to convey flow to its neighbors closer to the source, to be appropriately upsized. In this exercise, we assume that costs of pumping stations are additive (i.e., for each receptor basin there may be a dedicated pumping station in line with the modularity principles often adopted in design). The upsizing costs of pipelines are estimated as if the whole length $\Lambda_{i,j}$ were designed for flow $\Phi_{i,j}$, and need to be adjusted now to the total flow $F_{i,j} - \Phi_{i,j}$. The cost of transport of water between the i-th source and the j-th receptor can be then computed, in analogy with what outlined above, as:

$$E_{i,j} = \frac{E\left(D_{i,j}\right)\left(L_{i,j} - \Lambda_{i,j}\right) + \left(E\left(D^{cum}{}_{i,j}\right) - E\left(D^{base}{}_{i,j}\right)\right)\Lambda_{i,j} + \mathrm{E}(\mathrm{W}_{i,j})}{pva(0.05, 50)} + \frac{E'(S_{i,j})}{pva(0.05, 15)} + \psi_i \Psi_{i,j} \quad \textit{Equation 19}$$

Where we posit:

$$D^{cum}{}_{i,j} = 0.0104\left(F_{i,j} + \Phi_{i,j}\right)^{0.3803}$$
$$D^{base}{}_{i,j} = 0.0104\, \Phi_{i,j}{}^{0.3803} \quad \textit{Equation 20}$$
$$D_{i,j} = 0.0104\, \mathrm{F}_{i,j}{}^{0.3803}$$

And where E(*) is the expenditure function introduced before (Equation 9). Moreover, we have:

$$\Psi_{i,j} = \frac{F_{i,j}}{86400\eta}(365 * 24) g\left(\max(0, z_{obst\ i,j} - z_{p,i}, z_j - z_{p,i}) + J(\tau_i L_{i,j} + R_j)\right) \quad \textit{Equation 21}$$

Where now $z_{obst\ i,j}$ is the height of the expected obstacle to be met when crossing sub-basin divides between the i-th and j-th sub-basins. We consider the 75th percentile of catchment elevation for each sub-basin on the shortest path between the i-th and j-th sub-basins, and we assume that $z_{obst\ i,j}$ is the maximum of these elevations.

$$S_{i,j} = \frac{365\, \Psi_{i,j}}{(365 * 24) T_j} \quad \textit{Equation 22}$$

$$\mathrm{W}_{i,j} = 365 \mathrm{F}_{i,j} \left(1 - \frac{T_j}{365}\right) \quad \textit{Equation 23}$$

The levelized cost of water from the i-th source sub-basin potentially used in the j-th sub-basin is then given by:

$$LCoW_{i,j} = \frac{E_{i,j}}{365 F_{i,j}} + LCOWt \quad \textit{Equation24}$$

Table 10 summarizes the attributes computed for each sub-basin, related to the transfer of reclaimed water from the i-th to the j-th sub-basin.

Symbol	Description	Calculation
$F_{i,j}$	Potential Flow of reclaimed water within the SB	Equation 6, Equation 18
$L_{i,j}$	Length of the pipeline for transport to the SB's agricultural area	Equation 7
$D_{i,j}$	Diameter of the pipeline for transport to the SB's agricultural area	Equation 8, Equation 20
$E(D_{i,j})$	Cost per unit length of the pipeline for transport to the SB's agricultural area	Equation 9
$W_{i,i}$	Storage volume	Equation 13, Equation 23
$E(W_{i,i})$	Cost of storage volume	Equation 14
$\Psi_{i,j}$	Energy required for transport and distribution of reclaimed water	Equation 10, Equation 21
$S_{i,j}$	Power requirement for pumping	Equation 11, Equation 22
$E'(S_{i,j})$	Cost of pumping stations for distribution within the SB	Equation 12
$E_{i,j}$	Cost of water distribution within the SB	Equation 16, Equation 19
$LCoW_{i,j}$	Levelized cost of water within the SB	Equation 17, Equation 24

Table 10 – summary of computed attributes of each pair of related sub-basin (SB=sub-basin).

The above equations allow calculating the levelized cost of water for each potential source-receptor link. In order to allocate a given water availability at a source, receptors need to be ranked on the basis of cost criteria. The levelized cost as a function of the cumulative volume of reclaimed water potentially allocated from a source is the so called source's water-marginal cost curve (WMCC). The WMCC is a tool used for investment strategy decision support in the field of water infrastructure (McKinsey, 2009).

The actual volume of potentially reclaimed water at a source sub-basin that can be allocated to the receptor sub-basins is the minimum between reclaimed water availability at the source and irrigation demand in its neighborhood. The difference of these two terms represents the local surplus or deficit of reclaimed water with respect to irrigation requirements. Demands of receptors entailing a cost above a given threshold can be excluded.

The amount allocated from a source to any of its cost-ranked receptors is computed as the potential flow, if the sum of all potential flows up to the receptor's rank does not exceed availability, else it is calculated as the difference between availability and the sum of potential flows for all receptors featuring lower cost.

A receptor sub-basin may belong to the neighborhood of, hence be allocated water from, more than one source sub-basin. In this case, a surplus may result from the sum of allocations. A surplus may occur also when restricting potential flows with a cost threshold.

In this assessment, we refer to three cost scenarios:

(1) case when reuse requires developing all infrastructure from scratch (pipelines, pumping stations and water storage);

(2) case when pipelines and pumping stations must be built, but storage can be made using existing infrastructure;

(3) case when all infrastructure exists, and the costs are limited to treatment and energy.

For each of the above cases, we rank receptors based on the corresponding costs. For each source sub-basin considered in the EU, the calculation yields the demand in the neighbourhood that can be met under no restriction on costs, and with costs not exceeding a threshold of 0.25, 0.50, 0.75, 1.00 Euro/m^3, in addition to the corresponding local surplus or deficit.

Based on the above assumptions, we compute the variables summarized in Table 12.

Cost scenario #	costs included	target	variable	meaning
1	total costs	source	demand	demand in the neighborhood
1	total costs	source	Cost1demand25	demand that can be met with costs <=0.25Euro/m3
1	total costs	source	Cost1demand50	demand that can be met with costs <=0.5Euro/m3
1	total costs	source	Cost1demand75	demand that can be met with costs <=0.75Euro/m3
1	total costs	source	Cost1demand100	demand that can be met with costs <=1Euro/m3
1	total costs	receptor	Cost1alloc	supply that can be allocated
1	total costs	receptor	Cost1alloc25	supply that can be allocated with costs <=0.25Euro/m3
1	total costs	receptor	Cost1alloc50	supply that can be allocated with costs <=0.5Euro/m3
1	total costs	receptor	Cost1alloc75	supply that can be allocated with costs <=0.75Euro/m3
1	total costs	receptor	Cost1alloc100	supply that can be allocated with costs <=1Euro/m3
1	total costs	receptor	Cost1surplus	surplus of receptor after allocation at 1 Euro/m
2	total costs - storage	source	Cost2demand25	demand that can be met with costs <=0.25Euro/m3
2	total costs - storage	source	Cost2demand50	demand that can be met with costs <=0.5Euro/m3
2	total costs - storage	source	Cost2demand75	demand that can be met with costs <=0.75Euro/m3
2	total costs - storage	source	Cost2demand100	demand that can be met with costs <=1Euro/m3
2	total costs - storage	receptor	Cost2alloc	supply that can be allocated
2	total costs - storage	receptor	Cost2alloc25	supply that can be allocated with costs <=0.25Euro/m3
2	total costs - storage	receptor	Cost2alloc50	supply that can be allocated with costs <=0.5Euro/m3
2	total costs - storage	receptor	Cost2alloc75	supply that can be allocated with costs <=0.75Euro/m3
2	total costs - storage	receptor	Cost2alloc100	supply that can be allocated with costs <=1Euro/m3
2	total costs - storage	receptor	Cost2surplus	surplus of receptor after allocation at 1 Euro/m
3	only energy and treatment	receptor	Cost3demand25	demand that can be met with costs <=0.25Euro/m3
3	only energy and treatment	receptor	Cost3demand50	demand that can be met with costs <=0.5Euro/m3
3	only energy and treatment	receptor	Cost3demand75	demand that can be met with costs <=0.75Euro/m3
3	only energy and treatment	receptor	Cost3demand100	demand that can be met with costs <=1Euro/m3
3	only energy and treatment	receptor	Cost3alloc	supply that can be allocated
3	only energy and treatment	receptor	Cost3alloc25	supply that can be allocated with costs <=0.25Euro/m3
3	only energy and treatment	receptor	Cost3alloc50	supply that can be allocated with costs <=0.5Euro/m3
3	only energy and treatment	receptor	Cost3alloc75	supply that can be allocated with costs <=0.75Euro/m3
3	only energy and treatment	receptor	Cost3alloc100	supply that can be allocated with costs <=1Euro/m3
3	only energy and treatment	receptor	Cost3surplus	surplus of receptor after allocation at 1 Euro/m

Table 12 – variables considered in the assessment of reuse costs.

The above cost model makes assumptions on the following parameters:

- Cost of energy
- Cost of storage
- Duration of the irrigation period
- Discount rate
- Depreciation period of pipelines
- Depreciation period of storage
- Depreciation period of pumping stations
- Incidence of O&M costs of pipelines
- Incidence of O&M costs of storage
- Incidence of O&M costs of pumping stations.

In addition, the model assumes a roughness coefficient and an energy gradient in the Hazen-Williams formula used for the sizing of pipes. As these are typical, and largely conventional, engineering assumptions, we ignore these two parameters in the sensitivity analysis. In order to estimate a plausible upper and lower range for the computed levelized costs of water, we consider two scenarios, which we label as "more favorable" and "less favorable" respectively. In the former, we change the parameters from the base assumptions to values which systematically reduce costs; in the latter, on te contrary, we alter the base values so to increase the costs. Table 11 shows the values considered in the exercise.

Parameter	**Units**	**Base value**	**More favorable**	**Less favorable**
Cost of energy	€/kWh	0.1	0.05	0.15
Cost of storage	€/m3	5	2	8
Duration of the irrigation period	Days	120	180	70
Discount rate	%	5	2	7
Depreciation period of pipelines	Years	50	75	25
Depreciation period of storage	Years	50	75	25
Depreciation period of pumping stations	Years	15	20	10
Incidence of O&M costs of pipelines	%	3	1	5
Incidence of O&M costs of storage	%	1	0.5	1.5
Incidence of O&M costs of pumping stations.	%	1.5	0.5	2.5

Table 11 – alteration of model parameters in the global sensitivity analysis.

With reference to the two scenarios, we conducted a simplified global sensitivity analysis of the cost model by computing the levelized costs of water for each source-receptor link identified as detailed above. Figure 7, Figure 8 and Figure 9 show the scatter plots of costs under base and altered conditions, including all costs (Figure 7), all costs excluding storage (Figure 8) and only energy and treatment costs (Figure 9). From the plots, it is apparent that the overall ranking of source-receptor links does not change appreciably, the dispersion of points being always very narrow. This indicates that the cost analysis is sufficiently robust with respect to the identification of priorities for water allocation.

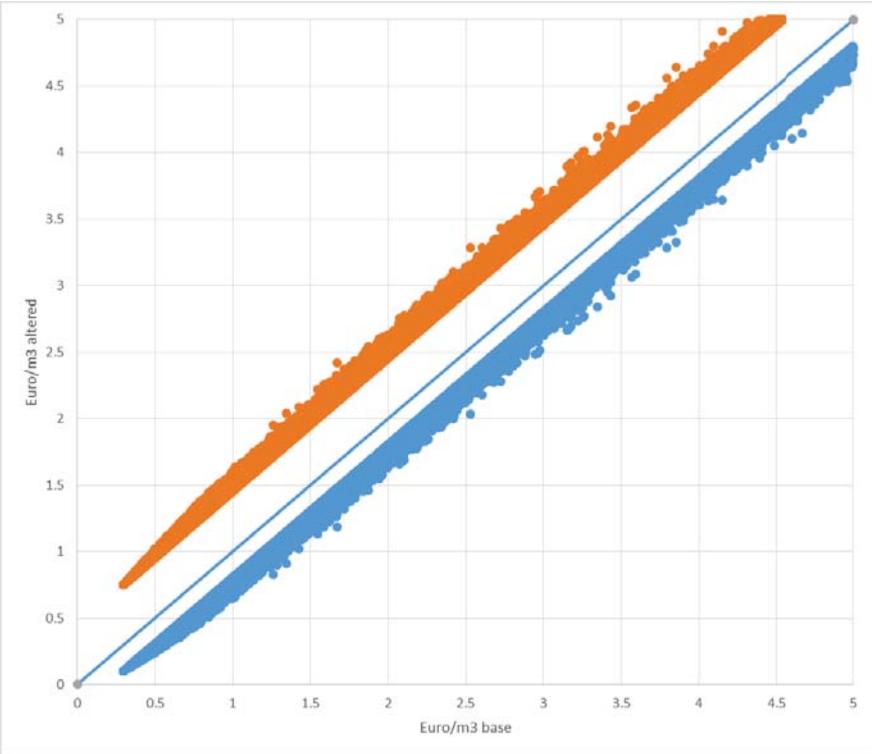


Figure 3 – Levelized costs including pipelines, pumping stations, storage, energy and treatment: comparison of the base case and altered values (orange=less favorable ; blue=more favorable), using parameters as per Table 11.

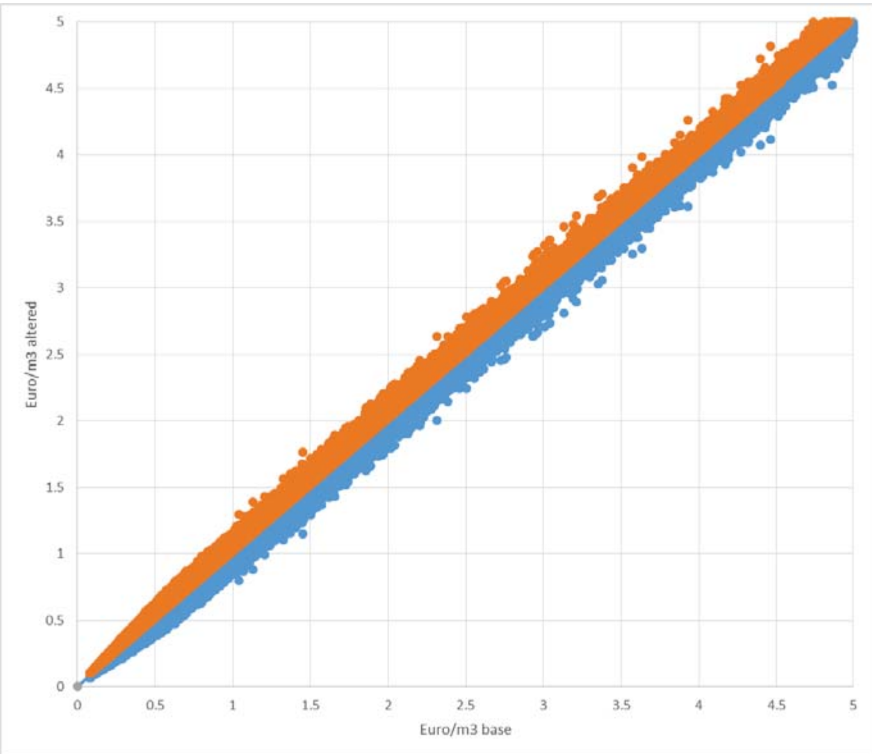


Figure 4 – Levelized costs including pipelines, pumping stations, energy and treatment: comparison of the base case and altered values (orange=less favorable; blue=more favorable), using parameters as per Table 11.

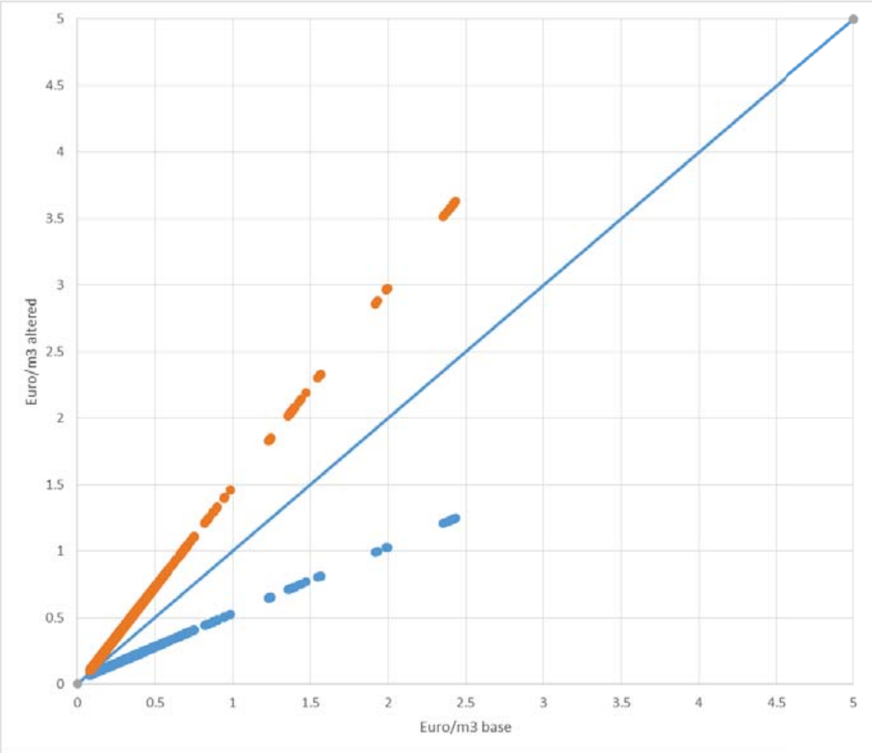


Figure 5 – Levelized costs including energy and treatment: comparison of the base case and altered values (orange=less favorable; blue=more favorable), using parameters as per Table 11.

Absolute costs may change significantly (especially when energy and treatment costs are considered alone) but in a very predictable way as per the narrow scattering. When total costs are considered, considering a more favorable alteration is practically equivalent to reducing costs of about 0.25 Euro/m3 while a less favorable alteration increases costs of about 0.5 Euro/m3 (Figure 7). The alteration of energy and treatment costs alone is practically equivalent to halving (for more favorable conditions) or multiplying by 1.5 (for less favorable conditions) the levelized costs (Figure 9). When total costs excluding storage are considered, the alterations have much less apparent effects (Figure 8).

Crop model

The EPIC model (Sharpley and Williams, 1990) was originally developed by the US Department of Agriculture, and is now maintained and developed by the Texas A&M University. It is an open-source code extensively used worldwide for crop simulations. The model has been widely used for the simulation of crop yields, nitrogen and phosphorus balances, and water requirements. The existing EPIC setup is used by the JRC in the context of other European scale assessments. The EPIC model has been validated against independent yield data (see § 4). EPIC model simulations have been used extensively in the last years for a number of assessments by the JRC, including a study supporting the Impact Assessment of the Water Blueprint in 2012 (de Roo et al., 2012).

Demand is estimated on the basis of calculated irrigation water requirements. We selected the biophysical model EPIC because it simulates crop production under different farming practices and operations including fertilization and irrigation application rates and timing and because it considers nutrient losses to the environment (N leaching and runoff) (Figure 3). In addition, it has been thoroughly evaluated and applied from local to continental scale (Gassman et al. 2005) and used in global assessments (Liu et al. 2007). The model has been applied for irrigation scheduling assessment (Wriedt et al. 2009), and biofuels production (Van der Velde et al. 2009).

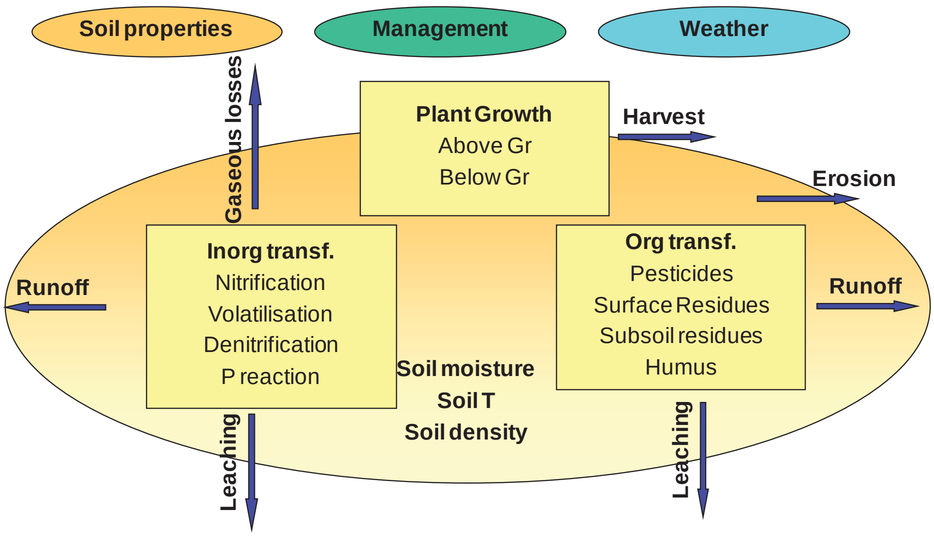


Figure 6. The EPIC model structure.

Furthermore the model is already integrated in a GIS system working at European scale (Bouraoui et al. 2007). The GIS system includes all the data required for EPIC modelling (meteorological daily data, soil profile data, landuse data with crop distribution and agriculture management data) and all necessary sets of attributes required to simulate different strategies, management and scenarios.

Wheat, barley, maize, rapeseed, oats, rye are major crops grown in Europe, while other crops are more important in specific regions such as olive and fruit trees in southern Europe or potatoes and sugar beet in Central and Northern Europe. There are many different cultivars adapted to different climate and environments and characterized by peculiar growth properties and productivity. Specific information on crop cultivars are not easily available at European scale but these information are important in order to represent this spatial variability in the model.

In this assessment, we make use of the results of the EPIC model setup at European scale available at the JRC corresponding to “baseline” conditions, i.e. supposed to reflect the actual current levels of irrigation. Under this scenario, crop water requirements (m3/year) were estimated at the cells of a regular 5km x 5 km grid across Europe.

The model setup used to estimate the average irrigation requirements is based on crop distribution statistics defined at 5km resolution derived from the combination of CAPRI (Britz, 2004), SAGE (Monfreda et al., 2008) and GLC (Bartholomé and Belward, 2005). The amount of manure and mineral fertilization applied were retrieved from the Common Agricultural Policy Regionalized Impact (CAPRI) agro-economic model (Britz and Witzke, 2008) and crop production optimized according to EUROSTAT statistics at NUTS2 level (EUROSTAT, 2010a). Extension of irrigated land by crop was derived according to MIRCA dataset (Portmann, 2011) and applied irrigated volume were validated at country level by using EUROSTAT 2010 statistics (EUROSTAT, 2010b). Landuse and crop management is assumed constant for the whole period of simulation.

First we identified 4 main regions in Europe, by performing a Cluster Analysis considering the main parameters potentially influencing crop growth, such as climate (precipitation, temperature, evapotranspiration, etc..), soil type (texture, organic matter content, drainage, water storage capacity, etc.) landuse and crop management (irrigation, fertilization plans, etc.). The initial cluster included 9 regions (Figure 4) that were reduced to four macro regions. The crop parameters were adapted for these four macro-regions.

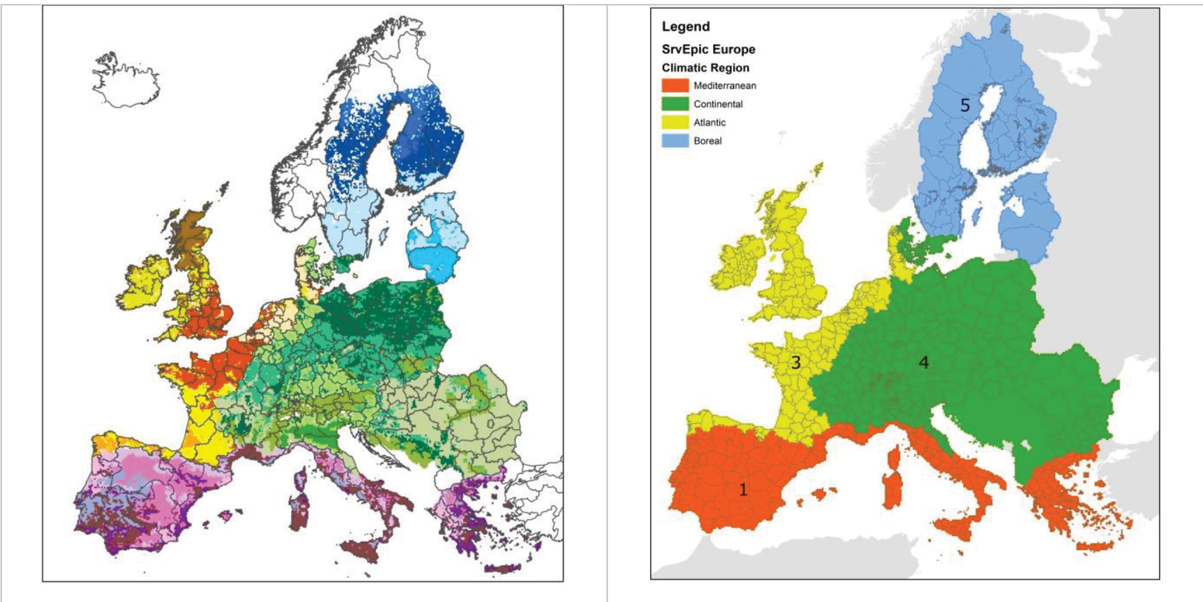


Figure 7 . Main clusters and selected regions for Europe detailed (left) and simplified (right).

The parameters affecting crop growth that were modified to customize EPIC to specific regional conditions included the optimal and base temperatures, the biomass growth rate parameter and the harvest index.

In our approach the optimization aimed at minimizing the differences between simulated and reported yields (EUROSTAT data) in different macro regions. We used the Multi Objective Genetic Algorithm (MOEA) library by Udías (2011) to optimize the selected set of parameters controlling the crop growth and productivity.

A comparison between simulated and reported annual yields (for last reporting period) aggregated at NUTS 2 level for all Europe is presented in Figure 5. The simulated yields compare well with the reported ones for all major crops, keeping in mind that the reported statistical data are not available for all the years considered (2008-2011) and that in some cases only data at country level is available. This analysis demonstrated the capability of the model to capture the spatial and annual variability of yields.

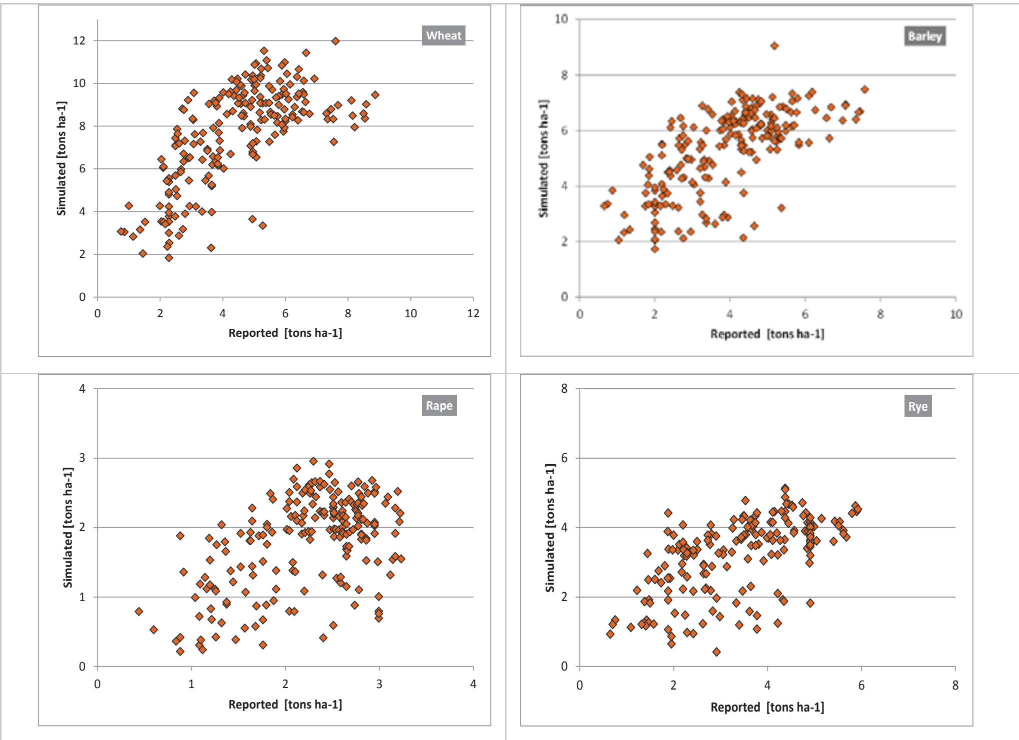


Figure 8. Scatter plots with means simulated yields versus reported regional crop yields for some major cereals, forage crops in Europe.

The EPIC model calculates annual crop water requirements, expressed in m3 per grid cell of 25 km2 (Figure 9). For each grid cell, we computed the hectares of agricultural land as the number of pixels of the 100 m x 100 m CLC 2012 map classified as "agricultural" (CLC 2012 level 1 code =2, with exclusion of level 3 code 231 – pastures) falling within the cell. Dividing the crop water requirements by the number of hectares allowed estimating a crop water requirement per unit area (unit requirement). Each sub-basin was attributed the unit requirement from the grid cells intersecting it, in proportion to the area of the grid cells on a sub-basin. The crop water requirement per sub-basin, I_i, was finally estimated as the unit requirement multiplied by the number of 100 m x 100 m agricultural CLC 2012 pixels falling within the sub-basin.

It should be stressed that we consider irrigation demand merely as the water required by crops. In reality, more water may be required for irrigation than what is actually used by crops. This water includes the losses along canals and pipelines, as well as the water evaporating or leaching below the root zone during field applications. We do not make a distinction here between crop water requirements and the actual amount required for irrigation. The latter is assumed to coincide with the former, i.e. we assume irrigation efficiency to be 100%, compatibly with the objective of this work which is an indicative comparison between requirements and availability. This aspect should be considered particularly when interpreting the results with reference to highly inefficient irrigation systems.

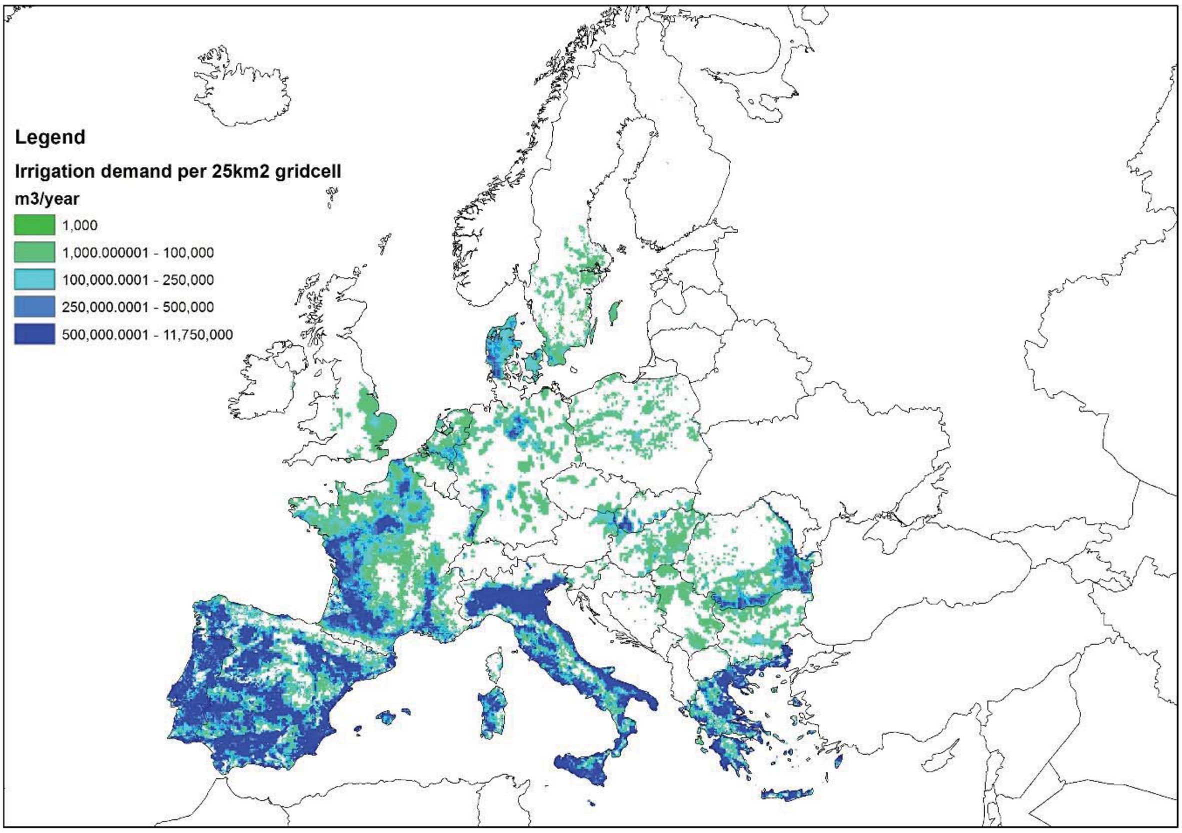


Figure 9- average irrigation water requirement used in this assessment, as computed with the EPIC model.

Quantification of the benefits from reuse.

Valuing the benefits that may stem from water reuse is overwhelmingly complex in general terms. One proxy of benefits is the willingness to pay of farmers for reclaimed water, which is extremely variable (for instance, Birol et al., 2007[1] estimate a willingness to pay higher than 0.6 Euro/m3 in Cyprus, while Tziakis et al., 2009[2], indicate less than 0.1 Euro/m3 for Crete).

Mattheiss and Zayas, 2016[3] analyse a case study in Braunschweig, Germany and another one in Sabadell, Spain. In Braunschweig, a survey has identified a willingness to pay of about 3 to 5 million euro/year for about 7 million m3/year of water reused to recharge aquifers, which

[1] Birol, E., P. Koundouri, and Y. Kountouris (2007), Farmers' demand for recycled water in Cyprus: A contingent valuation approach, in Wastewater Reuse—Risk Assessment, Decision-Making and Environmental Security, edited by M. K. Zaidi, pp. 267–278, Springer, Dordrecht, Netherlands.

[2] Tziakis, I., I. Pachiadakis, M. Moraittakis, K. Xideas, G. Theologis and K. P. Tsagarakis (2009), Valuing benefits from wastewater treatment and reuse using contingent valuation methodology, Desalination, 237, 117–125.

[3] Mattheiss, V., Zayas, I., Social and environmental Benefits of water reuse schemes – economic considerations for two case studies. DEMOWARE project deliverable 4.4, 2016. http://demoware.eu

could be interpreted as a valuation of water to improve flow regimes between 0.4 and 0.7 Euro/m3. In Sabadell, the willingness to pay of households for irrigation of green areas and street cleaning is estimated to exceed 5.5 million Euro/year, and the water demand for these activities is estimated at 1.1 million m3/year, indicating a value of water in the order of 5 Euro/m3.

Arborea et al., 2017, quantify the benefits of reusing water for irrigation in Puglia in the order of slightly less than 0.5 Euro/m3, including the direct and option benefits for the farmers and the benefits of maintaining good groundwater status.

Molinos_Senante et al., 2011[4], quantify the benefits of reuse using shadow prices of pollutants (suspended solids, nutrients and Chemical Oxygen Demand) not being discharged to rivers (therefore assuming the impact of such pollutants through irrigation would be negligible). In addition, they consider a sale price of reclaimed water of 0.9 Euro/m3. The total net benefits summing these components are estimated at a mean value of 1.22 Euro/m3 for 13 wastewater treatment plants in Spain.

Maton et al., 2010, conduct a cost-benefit analysis for water reuse in western Crete, and show that net benefits of reuse depend significantly on the level of stress on water resources; for cases of high water stress, net benefits range between 0.35 and 1.92 Euro/m3. Alcon et al., 2010[5], estimate the Segura river basin population's willingness to pay for irrigation reuse at about 0.3 Euro/m3, which is presented as the non-market value of reused water. This should be summed to the willingness to pay of farmers or market value of reclaimed water, so that the overall value of reclaimed water can be arguably around 0.5 Euro/m3. Birol et al., 2009[6] present an estimate of the willingness to pay for aquifer recharge by local residents in Cyprus of about 1.3 Euro/m3.

In the context of the AQUAMONEY EU-funded project[1], the willingness to pay of the public has been assessed for different actions improving water quality, safety and security in a few case studies across Europe (Table below – case studies). The case studies highlight a significant willingness to pay of households for a more sustainable management of water resources. This may support the idea that a part of the costs of water reuse could be borne by society/taxpayers and not only by the farmers alone, since water reuse generates additional benefits to society.

Case	**Motivation**	**Willingness to pay**
Vienna (AT)	Reduce flooding frequency and improve water quality	About 52 to 78 €/household/year
Hungary	Reduce flooding frequency and improve water quality	About 35 to 54 €/household/year

[4] Molinos-Senante, M., Hernandez Sancho, F., Sala Garrido, R., Cost-benefit analysis of water reuse projects for environmental purposes: a case study for Spanish wastewater treatment plants. Journal of Environmental Management, 92 (2011) 3091-3097. DOI: 10.1016/j.jenvman.2011.07.023

[5] F. Alcon, F. Pedrero, J. Martin-Ortega, N. Arcas, J. J. Alarcon, and M. D. de Miguel, The non-market value of reclaimed wastewater for use in agriculture: a contingent valuation approachSpanish Journal of Agricultural Research 2010 8(S2), S187-S196. URL: www.inia.es/sjar

[6] Birol, E., P. Koundouri and Y. Kountouris (2009), Assessing the economic viability of alternative water resources in water scarce regions: The roles of economic valuation, cost–benefit analysis and discounting, paper presented at 27th International Association of Agricultural Economists Conference, Beijing, 16–22 Aug.

[1] http://www.ivm.vu.nl/en/research-new/environmental-economics/projects/aquamoney/project-deliverables/index.aspx

Braila (RO)	Reduce flooding frequency and improve water quality	About 9 to 22 €/household/year
Odense (DK)	Reduce flooding frequency and improve water quality	About 57 to 192 €/household/year
Po and Reno river basins (IT)	Ensure water availability for different sectors (agriculture, industry, energy,…) and the environment	About 10 to 40 €/household/year
Serpis (Jucar) river basin (ES)	Ensure domestic water supply and improve/maintain ecological status	297 €/household/year for supply; 64 to 104 for ecological status
Lesvos (EL)	Ensure domestic water supply and improve/maintain ecological status	287 €/household/year for supply; 44 to 253 for ecological status

These examples highlight the large variability in valuation of water used to reduce water stress, and the uncertainty due to their high case-specificity. If a benefit of water reuse of 0.5 Euro/m3 was assumed, which is in the mid-lower end of the cases examined above, and may be argued to represent as a first approximation the combined market and non-market value of water reuse in Europe, provided it contributes to water stress reduction, there would be willingness to pay the assumed costs of water reuse.

Calculation of administrative burden for policy options for water reuse for agricultural irrigation (Ir1, Ir2 and Ir3, if followed) and aquifer recharge (Re1, if followed and Re2).

Minimum quality requirements for water reuse for irrigation and aquifer recharge						Tariff (€ per hour)	TIme (minutes)	Price (per action)	Freq (per year)	Nbr of entities	Total number of actions	Equipment costs (per entity & per year)	Outsourcing costs (per entity & per year)	Total Administrative Costs	Business As Usual Costs (% of AC)	Total Administrative Burdens (AC - BAU)
No.	Art.	Orig. Art.	Type of obligation	Description of required action(s)	Target group											
1			Application for individual authorisation or exemption for water reuse for **agricultural irrigation**	Producing new data	water operators would need to perform risk assessment and adjust/ issue permits at UWWTP level for water reuse for agricultural irrigation	32	1.200,00	641	1	3.500[36]	3.500			2.244.176	0%	2.244.176
2			Application for individual authorisation or exemption for water reuse for **aquifer recharge**	Producing new data	water operators would be required to perform risk assessment for water reuse for the 220 sites of aquifers which could be potentially recharged with reclaimed water	32	1.200,00	641	1	220[37]	220			141.063	0%	141.063

[36] The number of UWWTPs estimated as a percentage similar to the ratio of volume that can be allocated at costs <0.5 euro/m3, divided by total volume available at WWTPs (see Figure 10 in Section 5 of the Impact assessment report). This is about 13%, therefore 0.13 x 25,000 = 3250.

[37] The estimated number of aquifers in the EU (see Annex 6)

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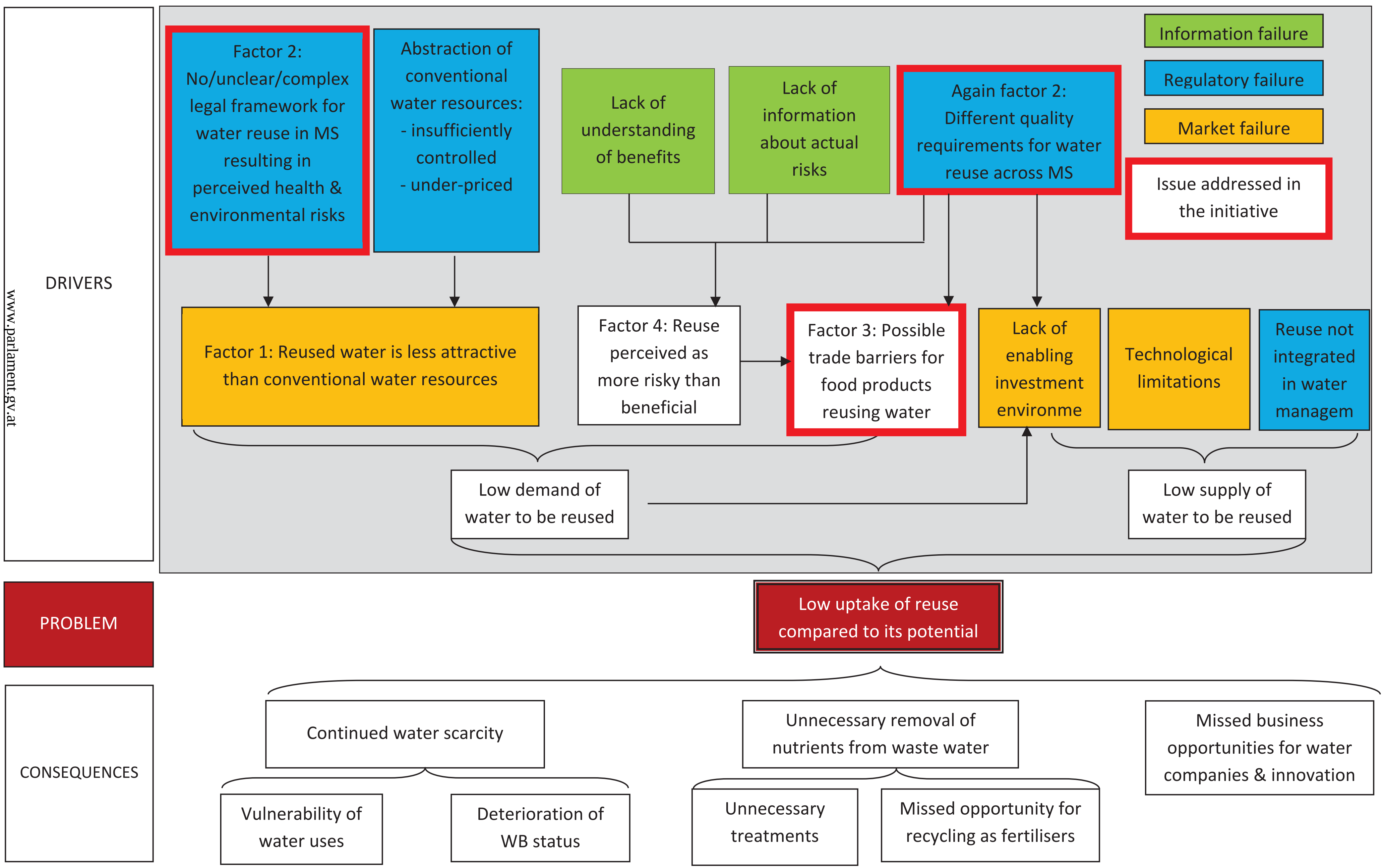
Annex 5 - Problem tree



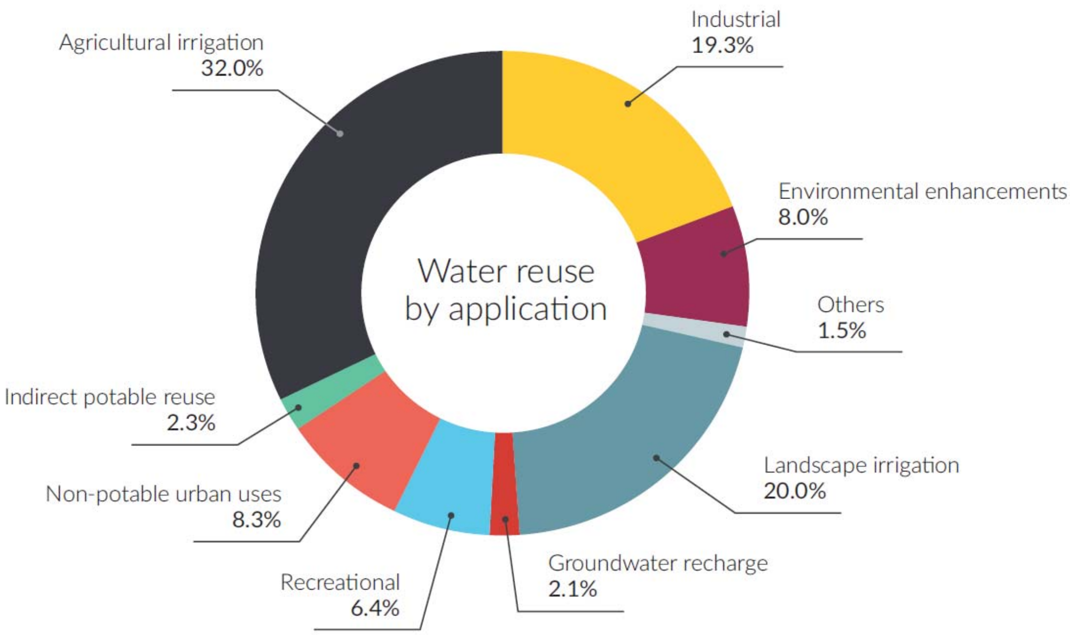
Annex 6 - The purposes and benefits of reusing water - situation in selected Member States

In this report, the term "water reuse" is used interchangeably with the terms "reuse of treated wastewater" and "use of reclaimed water". They all stand for the use of water which is generated from wastewater and which, after the necessary treatment, achieves a quality that is appropriate for its intended uses (taking account of the health and environment risks and local and EU legislation). Unless it is specified otherwise, the source of reclaimed water is urban wastewater in accordance with the Urban Waste Water Directive. "Water reuse" refers to planned or intended water reuse, namely water reuse schemes that are developed with the goal of beneficially reusing a recycled water supply. Water reuse for irrigation typically allows substituting abstractions from depleted aquifers with reclaimed water which would otherwise be discharged to rivers. In contrast, unplanned water reuse refers to uncontrolled reuse of treated wastewater after discharge. An example of unplanned reuse of wastewater is when effluents from a wastewater treatment plant are discharged upstream in a river while river water is abstracted downstream for the production of drinking water or for irrigation.

Treated wastewater may be used for a wide variety of purposes, and there is continuing innovation in potential uses. These include:

- Contributing to environmental objectives/making water available for future uses such as aquatic ecosystem restoration or creation of new aquatic environments, stream augmentation (especially in dry seasons), aquifer recharge (e.g. for saline intrusion control or later abstraction for use such as the further uses below).
- Agricultural/horticulture uses such as irrigation of crops (food and non-food), orchards and pastures.
- Industrial uses such as cooling water, process water, aggregate washing, concrete making, soil compaction, dust control etc.
- Municipal/landscape uses such as irrigation of public parks, recreational and sporting facilities, private gardens, road sides, street cleaning, fire protection systems, vehicle washing, toilet flushing, dust control.

Figure 25: Global water reuse after advanced (tertiary) treatment: Market share by application



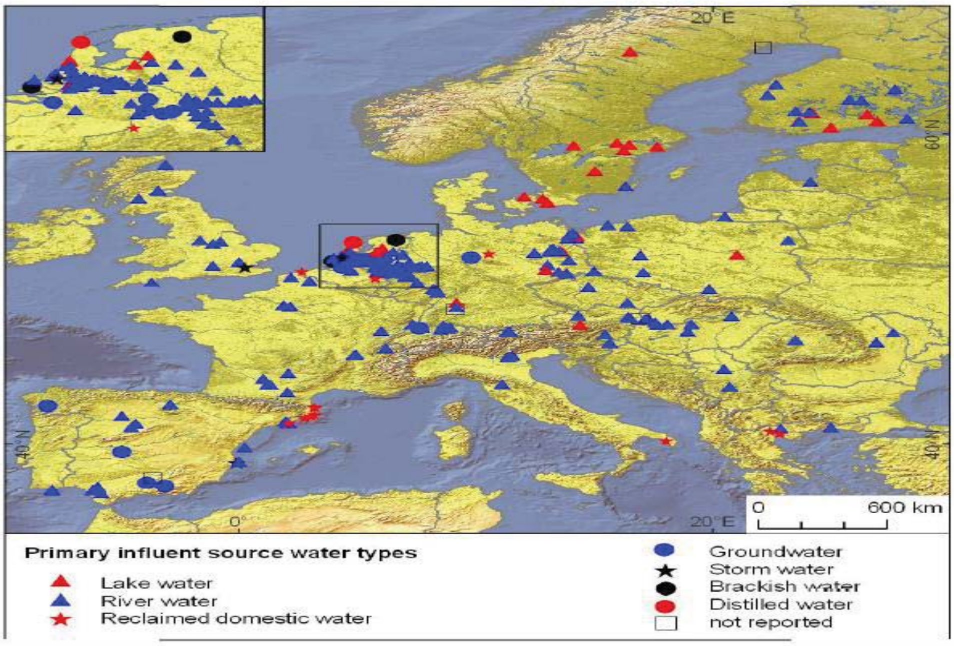
Source: Lautze et al. (2014, Figure 2, p. 5, based on Global Water Intelligence data).

Reusing water for aquifer recharge

Aquifer recharge is a hydrological process where water moves downward from the soil surface towards groundwater. Recharge occurs both naturally (through the water cycle) and man-induced (i.e. artificial aquifer recharge), where rainwater, surface water and/or reclaimed water is routed to the subsurface. Artificial groundwater recharge aims at increasing the groundwater potential and it can effectively help preventing saline intrusion in depleted coastal aquifers. The 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). 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). However, in the first public consultation, aquifer recharge was one of the most often mentioned additional appropriate uses, in particular in order to prevent saline intrusion.

As illustrated in Figure 26, managed aquifer recharge (MAR) is a practice relatively widespread in Europe. In a comprehensive but non-exhaustive review FP7 project DEMEAU could identify about 270 sites (220 being still active), with a spatial distribution covering most of the European countries. Different water sources can be used for MAR. River and lake water and groundwater have been the most commonly used influent so far, while treated waste water has remained rather limited (12 sites out of 270 in the DEMEAU catalogue, in Belgium, Germany, Italy, Greece and Spain). In most case recharge with reclaimed water is done via surface spreading and more limitedly injection (4 sites).

Figure 26: spatial distribution of MAR sites in Europe and primary source of water (Hannappel et.al, 2014)



In addition to the benefits in terms of freshwater availability, there is a wide range of environmental benefits associated with reuse schemes, in particular:

- Reducing pressure on water bodies, maintaining ecological flows and protecting aquatic ecosystems;
- Preserving high-quality groundwater for more sensitive uses (e.g. drinking water production);
- Decreasing the nutrient pollution load directly discharged to rivers or other waterbodies, and the associated risks of eutrophication;
- Improving the quality of irrigation water and bathing waters. Currently, irrigation water sources should comply with the definition of "*clean water*" at the point of use, i.e. water "*that does not contain micro-organisms, harmful substances in quantities capable of directly or indirectly affecting the health quality of food*" according to Article 2 of Regulation 852/2004. Further details on implementation of this requirement are given in the Commission Notice 2017/C 163/01[38] "Guidance document on addressing microbiological risks in fresh fruits and vegetables at primary production through good hygiene";

[38] 2017/C 163/01 - http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AC%3A2017%3A163%3ATOC

- Restoring or enhancing biodiversity and the various ecosystem services associated with wetlands;
- Protecting groundwater resources from saline intrusion, particularly in islands and coastal areas (through groundwater recharge);
- Reducing the amount of organic fertilisers applied to irrigated fields, thereby contributing to conserving natural resources of phosphorus and reducing environmental impacts associated with fertilisers' manufacture;
- Decreasing the level of purification/treatment necessary for discharging wastewater, thereby reducing energy consumption associated with water treatment, while guaranteeing compliance with all the relevant legislation.

In the second open public consultation, a majority of respondents (more than 70% across and within different categories of respondents) perceive the environmental benefits of reusing water for agricultural irrigation for:

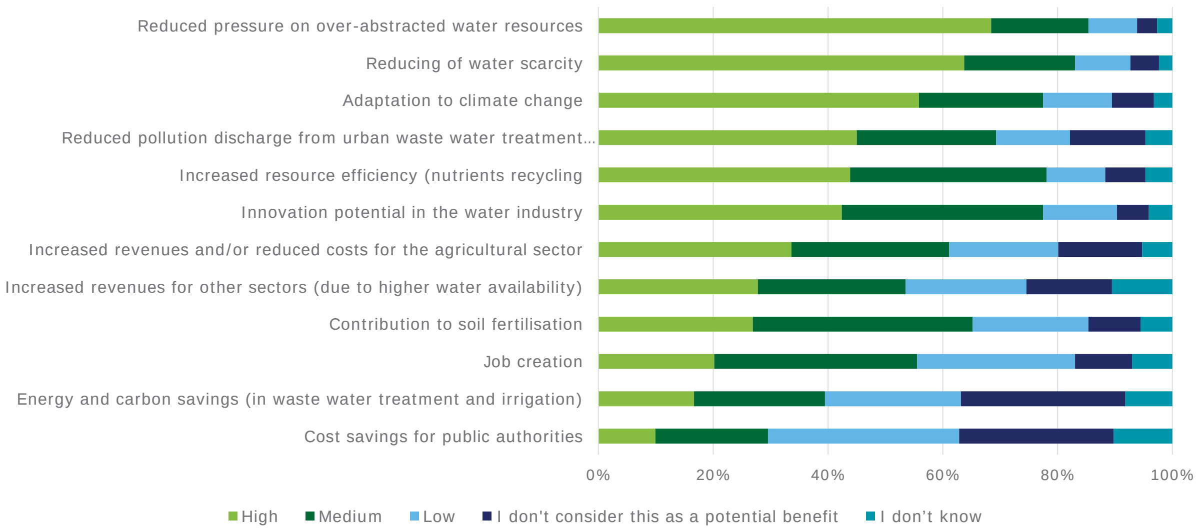
- **reducing pressure on resources** that are over-abstracted,
- **reducing water scarcity**, and
- **thereby adapting to climate change**.

These potential benefits are particularly highlighted by respondents from the sanitation, drinking water and environment/climate sectors as well as respondents from countries in regular situation of water stress or more generally from Southern EU (over 80% of respondents within each of these categories).

A large number of respondents (more than 70% of all respondents) also identify the following environmental benefits:

- **increased resource efficiency**,
- **enhanced innovation potential** in the water industry, and
- **reduced pollution discharge** from urban wastewater treatment plants into rivers. In this respect, a utility provider recognised that capture of effluents currently discharged in coastal areas would benefit the environment. An academic representative noted that the increased stringency on water treatment plants to produce high quality reused water would indirectly benefit the environment by enhancing the global quality of water discharged.

Figure 27: Overview on potential benefits of water reuse in agricultural irrigation, for all respondents



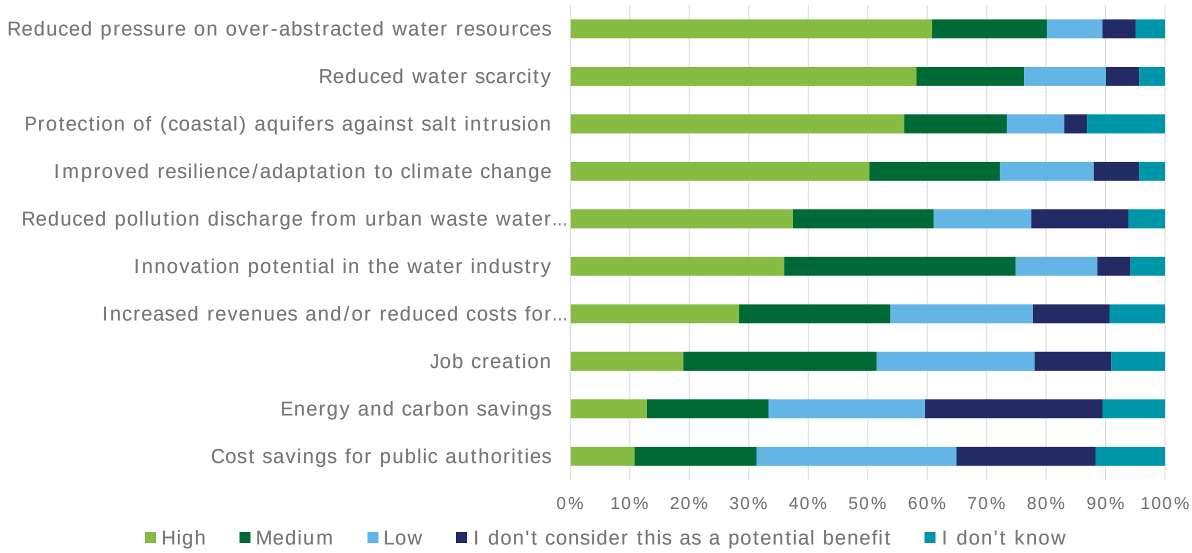
A large share of respondents (more than 70%) perceive the environmental benefits of reusing water in aquifer recharge for:

- reducing pressure on resources that are over-abstracted: an industry association representing French water companies highlighted in particular the benefits of the limited evaporation allowed by water storage in the aquifer,
- reducing water scarcity, and
- protecting coastal aquifers against salt intrusion.

In addition, water reuse is perceived by a significant number of respondents across all sectors (over 70%) to contribute to fostering the innovation potential in the water industry.

A large proportion of respondents also considers adaptation to climate change and reduced pollution discharge into rivers as benefits of reusing water for aquifer recharge, although they are considered slightly more moderate than the first ones and appear less consensual across sectors and categories of stakeholders. Several respondents commented on the benefits of aquifer recharge to reduce pollution discharge, e.g. by reducing water exposure to various contaminations and eutrophication occurring at the surface of the earth and through filtering services from the soils.

Figure 28: Views on potential benefits of water reuse in aquifer recharge



Because the uptake of water reuse solutions will remain very limited at the EU level in the baseline scenario, these other benefits are unlikely to materialise at a wide scale across the EU.

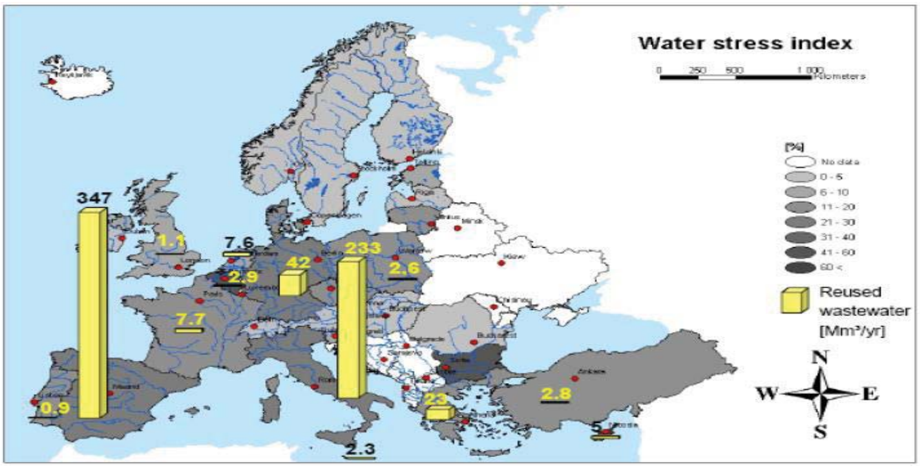
On the other hand, environmental risks potentially associated with treated wastewater reuse, such as chemical contaminants from inorganic salts, nutrients, heavy metals and micro pollutants, e.g. detergents, would also remain minimal. Emerging pollutants, such as pharmaceutical products and their metabolites, personal care products, household chemicals, food additives, etc., in particular, represent a growing environmental concern. At the moment, however, there is not yet full scientific consensus on the actual level of risks associated with many of these various substances and further research is thus required.

Current status of water reuse in the EU – selected Member States

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 or less than 0.5% of annual EU freshwater abstraction (Hochstrat et al., 2006). No complete and harmonised data are available on the current volume of treated wastewater being reused in the EU; however **the current volume of reused treated wastewater in the EU** can be estimated at **1,100 million m^3/year** or 0.4% of annual EU freshwater abstractions (BIO, 2015).

In 2006, Spain and Italy jointly accounted for about 60% of the total EU treated wastewater reuse volume, predominantly for agricultural irrigation and for urban or environmental applications. 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 for various purposes. 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. Figure 29 below presents the amount of reused treated wastewater in European countries, as estimated by FP5 project AQUAREC in 2006, relative to the spatial distribution of water stress.

Figure 29: Reuse of reclaimed water in Europe (Hochstrat et al., 2006)

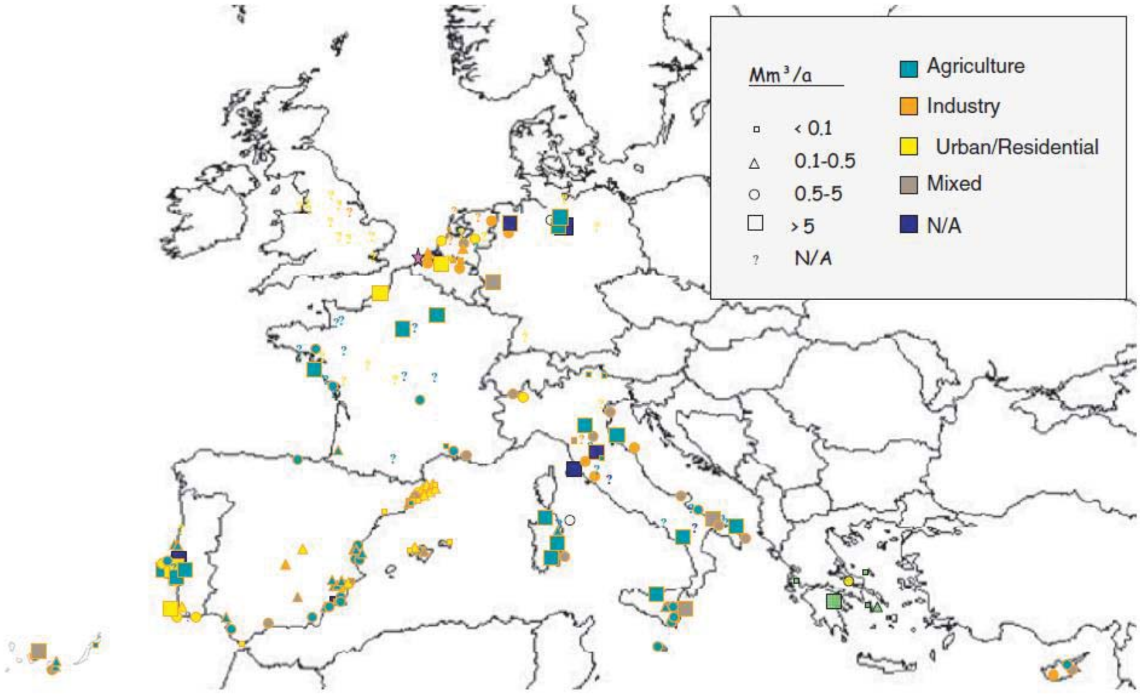


The literature suggests that some countries have little or no evidence of any water reuse schemes; this is understandably the case in countries with high water availability and low drought risk, such as Ireland or Finland. However, some Member States that have experienced severe water stress recently are also in this situation, including some Baltic countries (e.g. Latvia and Lithuania), as well as Eastern European countries (Romania, Bulgaria, Slovakia, Slovenia, and Hungary). It is important to highlight that the southern and Baltic states usually have efficient urban waste water treatment plants, hence there is potential for reusing reclaimed water. Such potential is more limited in Eastern European states, where many treatment plants are not yet equipped with appropriate treatment technologies at present. However the need for upgrade and refurbishment of these treatment plants to comply with the UWWTD also provides an opportunity for considering water reuse as a possible solution at lesser costs than would be needed to integrate water reuse at a later stage.

Member States in which water reuse is being practiced include Scandinavian countries (Sweden, Denmark), southern European states (Spain, Cyprus, Malta, Italy, Greece, Portugal) as well as North-Western countries (France, Belgium, UK, Luxembourg, the Netherlands). In Luxembourg, Sweden and Denmark, water reuse is driven by high water prices and ecological concerns, especially during the summer. For instance, several Danish industries recycle wastewater, while in Sweden treated wastewater is used for irrigation purposes. Reuse of water for agricultural activities is also very widespread in southern European countries, although it must also be highlighted that water reuse in these countries is also driven by tourism, for example for irrigation of golf courses and parks. In European regions that are not water-scarce but experience episodic drought events, water recycling is becoming much more widespread and being implemented in the agricultural, urban and industrial sectors. This is the case for countries such as the UK and France, where competition for increasingly limited water resources during peak demand periods is driving interest in alternative sources. Even short dry spells in humid or temperate countries can trigger temporary restrictions in freshwater abstraction.

Furthermore, interest in water reuse implementation can be evaluated by considering the number and geographical spread of projects in Europe. Such an analysis was conducted in 2005 during the AQUAREC project (Figure 30). In the course of this Impact Assessment updated and consistent data on water reuse projects in Europe has been collected, in particular as concerns information already reported by Member States to Eurostat and to the Commission under the WFD and UWWTD. Given the relatively recent interest for these technologies in a number of Member States only very limited data is available at this stage and suggests the possible need for adapting existing reporting tools in the future for monitoring and evaluation of this policy area (Chapter 7).

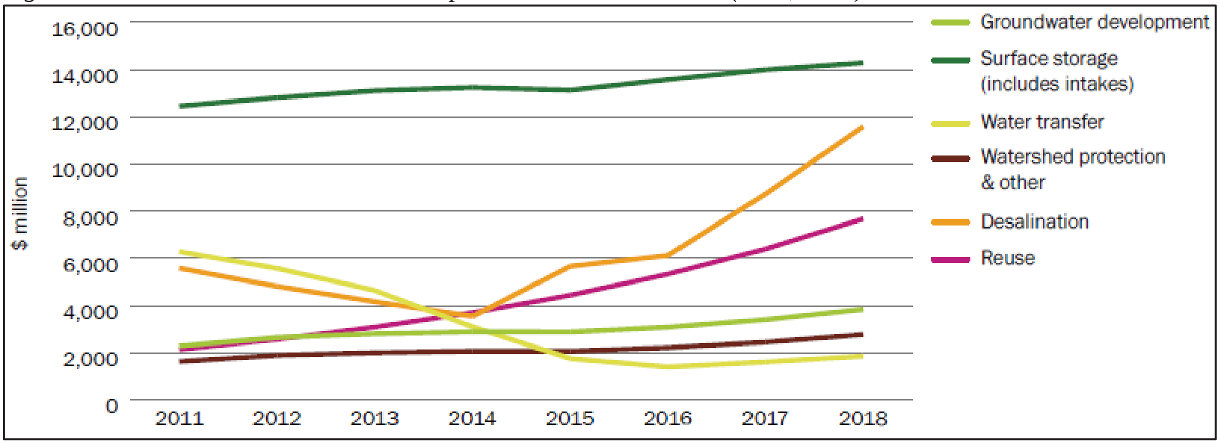
Figure 30: Identified water reuse projects in Europe, incl. their size and intended use (Bixio et al., 2005)



All information sources agree on the significant potential for further development of water reuse projects in the EU. Climate change pressures are likely to increase the level of interest in such solutions for both mitigating wastewater disposal impacts and episodic drought effects (Falloon et al., 2010). Moreover, a number of countries are developing the policy and – for those that do not possess suitable wastewater treatment technology – technical capacities needed to promote the uptake of water reuse solutions.

The global market for water reuse is expected (Global Water Intelligence, 2015) to be fast-growing in the coming years. Between 2011 and 2018 capital expenditure on advanced water re-use was expected to have grown at a compound annual rate of 20% (cf. Figure 31 as the global installed capacity of high quality water re-use plants grows from 7 km³/yr to 26 km³/yr.

Figure 31: Global water resources development market 2011–2018 (GWI, 2015)



As confirmed by the number of projects funded by the EU on this topic in the last decade and by experts in a dedicated workshop (cf. Annex 8) water reuse is an active field for research and innovation.

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

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,[39] 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

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

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 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 al., 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.

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^3[40]), 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

[40] Value of agricultural output (EUR) per m^3 of water added

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 m³/year (or 79% of total water demand). Groundwater abstraction is estimated at circa 6,125-6,925 million m³/year (19-22% of Spain´s total water demand) out of which 70-72% (4,300-5,000 million m³/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 €/m³ (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 €/m³ though during peak demand they can go beyond 1 €/m³.

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 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 million m³/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 m³/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

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.

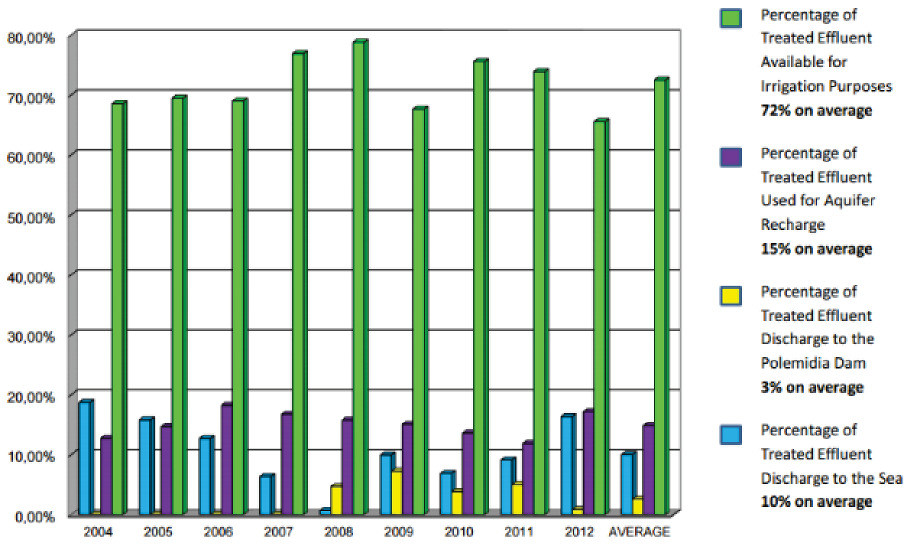
In terms of water stress, Cyprus is the most affected country of the European Union, with a water stress index of approximately 66%[41]. Domestic water use and agricultural irrigation are the two main sources of water demand in Cyprus.

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[42]% 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.

[41] Eurostat tsdnr310 | Publication date: 19 February 2016, CET (Water Exploitation Index - Percentage)
[42] For 2004-2013 – 89.32% according to competent authority communication

Figure 32: 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 m³/year for long term (2025)[43].

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.

Agricultural irrigation

In Cyprus, the use of recycled water has mostly been for irrigation and to mitigate the overdependence of agriculture on groundwater[44,45]. 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

[43] Ministry of Agriculture, Natural Resources and Environment Water Development Department River Basin Management Plan, April 2011
[44] 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
[45] 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

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.

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 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[46].

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.

Reused water tariffs in Cyprus range from 33%-44% of freshwater rates, ratios which appear typical for the EU Mediterranean islands[47]. 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

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

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 effluent but further research is on-going to assess whether they are being taken up by plants under field conditions. (Appendix D of AMEC study- 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 WFD, 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[48].

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[49]. 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.

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[48] MANRE,2005

[49] 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.

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 m³ treated wastewater per year, which is then re-abstracted for irrigation[50],[51].

France

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.[52]). At present, there are about 40 reuse schemes in France, most of which are dedicated to irrigation (agriculture, public areas, golf courses and

[50] Water Scarcity in Cyprus: A Review and Call forIntegrated Policy, Anastasia Sofroniou and Steven Bishop
[51] 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
[52] 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.

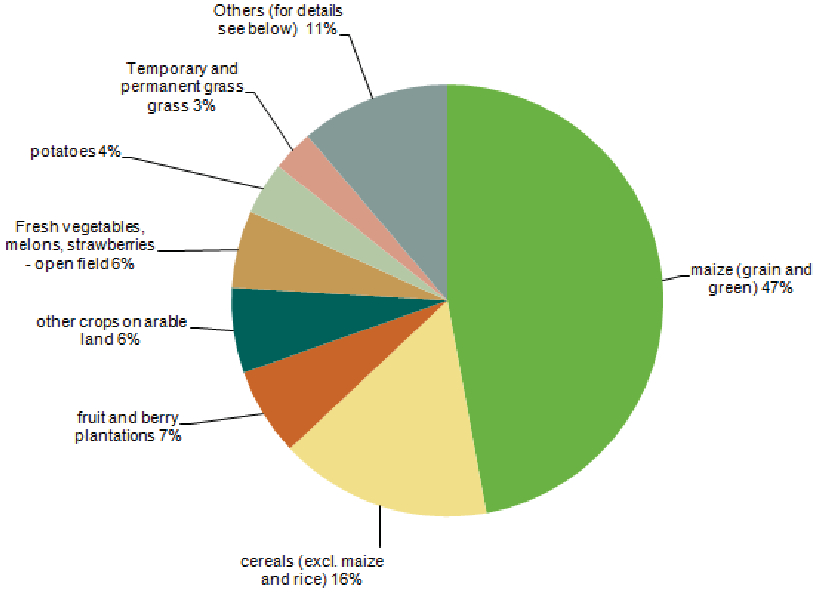
racecourses) (SYNTEAU, 2014). Latest available data indicate that around 55 reuse schemes are now in place in the country[53].

Agricultural irrigation

Agriculture is the main user of water in France (48% of the water used in 2004[54]). 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[55].

Figure 33: 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

[53] Communication from French competent authority
[54] France Nature Environnement, 2008.
[55] France Nature Environnement, 2008.

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)[56].

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[57]. 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[58].

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[59], covering two thirds of the demand for drinking water (BRGM, 2016).

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

[56] 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

[57] http://www.ecoumenegolf.org/XEauXLAZAROVA.pdf

[58] 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).

[59] http://www.eaufrance.fr/comprendre/les-milieux-aquatiques/eaux-souterraines

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[60].

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

In Greece the theoretical long-term annual freshwater availability is 72,000 million m^3/year[61]. 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[62])+>20%) with these 7 RBDs being among the twenty most water-scarce RBDs of Europe[63].

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.

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

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[60] 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

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

[62] 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)

[63] 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

million m^3/year)[64], while in the AQUAREC project the average annual wastewater reuse was estimated at 23 million m^3/year [65]. The future potential for wastewater reuse in Greece (2025) was modelled at 57 million m^3/year [66] in the AQUAREC project, while another study estimated it at 242 million m^3/year [67].

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%[68]. 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[69].

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[70].

Irrigation water in Greece is billed in a number of ways with the average price ranging between 0.02-0.70 €/m^3 [71] for volumetric billing, 73-286.3 €/ha [72] for flat rates by crop type and 45-243.1 €/ha for flat rates by irrigation system[73]. 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 [74].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

[64] 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.
[65] Hochstrat et al., 2006. Report on integrated water reuse concepts. Deliverable D19, AQUAREC project.
[66] Hochstrat et al., 2006. Report on integrated water reuse concepts. Deliverable D19, AQUAREC project
[67] 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
[68] 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.
[69] 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
[70] Eurostat data, Agri-environmental indicators
[71] Kalligaros, D., 2004. *The cost of irrigation water in Greece*, Postgraduate Thesis, Environmental Studies Department, University of the Aegean.
[72] OECD, 2010. *Agricultural Water Pricing: EU and Mexico,* http://www.oecd.org/eu/45015101.pdf
[73] OECD, 2010. *Agricultural Water Pricing: EU and Mexico,* http://www.oecd.org/eu/45015101.pdf
[74] Zotalis, K., Dialynas, E., Mamassis, N., and Angelakis, A.N., 2014. Desalination Technologies: Hellenic Experience, *Water*, *6*, 1134-1150; doi:10.3390/w6051134

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) 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.

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[75].

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[76]. A conservative estimate is that wastewater reuse in irrigated agriculture would increase by 10-20% up to 2025 (Appendix D of AMEC study - case study for Greece).

Aquifer recharge

In Greece, the average annual groundwater availability for abstraction is reported at 3,550 million m^3/year[77]. 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[78].

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"[79]. After communication with the

[75] 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
[76] 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
[77] Eurostat data, Water statistics, Agricultural statistics, Crop statistics, Agri-environmental indicators, Agricultural Census in Greece.
[78] 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.
[79] 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

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.

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

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.

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the management and conservation of water resources, 748 pages, Department of Water Resources and Environmental Engineering, National Technical University of Athens, Athens.

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[80].

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[81]; confirmed by other sources up to 2015,). Existing examples of artificial aquifer recharge are being implemented thanks to EU LIFE and FP7 funding:

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[80] 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

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

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 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[82]).

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)[83].

At present, no testing of artificial groundwater recharge with treated effluents has been reported: this practice is forbidden in Italy[84].

Romania

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.

[82] http://www.lifeaquor.it/file/649-A6_linee_guida_tecnico_operative_I.pdf
[83] 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
[84] The Ministerial Decree 2 May 2016, n.100 indicates the sources for groundwater recharge, which do not include wastewater.

In 2013, the Water Exploitation Index was 15.2 (Eurostat), which is below the EEA's threshold of 20% for water stress[85].

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[86].

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.

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

[85] 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)
[86] Romanian Waters

groundwater. The current potential for treated wastewater reuse in aquifer recharge, therefore, is effectively non-existent.

Comparison of MS regulations/guidelines on water reuse for agriculture and the proposed minimum quality requirements

The minimum quality requirements for water reuse in agricultural irrigation are compared with the national regulations from MS that have the most comprehensive standards developed specifically for water reuse practices including agricultural uses: Cyprus, France, Greece, Italy, Portugal and Spain. The regulations of Cyprus, France, Greece, Italy and Spain are included as regulations in the national legislation. In Portugal, the standards on water reuse are guidelines, but they are taken into consideration by the national government when issuing any water reuse permits in the country.

This comparison is not exhaustive but includes the following points:

- Parameters (microbiological and physico-chemical) and limit values
- Category of crops
- Irrigation method
- Risk management framework

The following tables (Table 1, 2, 3, 4 and 5) show different quality categories included in the minimum quality requirements and the MS standards for the reclaimed water quality.

Table 1. Category of reclaimed water quality for agricultural irrigation in MS standards and the minimum quality requirements proposed by JRC.

Analytical parameters/ Category of use	JRC	Cyprus	France	Greece	Italy	Portugal	Spain
CATEGORY A							
Verification monitoring							
Escherichia coli **(cfu/100ml)**	≤10; ≤100	≤5	≤250	≤5; ≤50	≤10; ≤100		≤100; ≤1,000
Fecal coliforms (cfu/100ml)						≤100	
Legionella **sp. (cfu/l)[a]**	≤1,000						≤1,000
Salmonella **sp.**					absence		absence [c]
Intestinal helminth eggs (eggs/l)	≤1[b]	absence				≤0.1	≤0.1
TSS (mg/l)	≤10	≤10	≤15	≤10	≤10	≤60	≤20
BOD_5 (mg/l)	≤10	≤10		≤10	≤20		
COD (mg/l)		≤70	≤60		≤100		
Turbidity (NTU)	≤5			≤2 median			≤10
Validation monitoring							
Escherichia coli **(log_{10} reduction)**	≥5						

Analytical parameters/ Category of use	JRC	Cyprus	France	Greece	Italy	Portugal	Spain
Total coliphages/F-specific coliphages/somatic coliphages (log_{10} reduction)	**≥6**						
***Clostridium perfringens* spores/Sulphite-reducing bacteria spores (log_{10} reduction)**	**≥5**						
Fecal enterococci (log_{10} reduction)			**≥4**				
F-specific RNA bacteriophages (log_{10} reduction)			**≥4**				
Sulphite-reducing bacteria spores (log_{10} reduction)			**≥4**				

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(a): Only if there is risk of aerosolization. (b): When irrigation of pastures or fodder for livestock. (c): after certain monitoring results is compulsory to conduct analysis of *Salmonella*.

JRC: 90% samples, maximum value in 10% samples. Cyprus: 80% of the samples. Greece: 80% samples and 95% samples. Italy: 80% samples, maximum value in 20% samples. Spain: 90% samples, maximum value in 10% samples.

The requirements of this Category 1 (Table 1) are to be applied for the irrigation of all types of crops, including food crops consumed raw with reclaimed water in direct contact with edible parts of the crop, and using any irrigation method. The only exceptions are described by Cyprus which indicates that it is forbidden the irrigation of leafy vegetables and bulbs consumed raw, and by Portugal that allows irrigation of vegetables consumed raw only by drip irrigation.

Table 2. Category of reclaimed water quality for agricultural irrigation in MS standards and the minimum quality requirements proposed by JRC.

Analytical parameters/ Category of use	JRC	Cyprus	France	Greece	Portugal	Spain
CATEGORY B						
Verification monitoring						
***Escherichia coli* (cfu/100ml)**	**≤100; ≤1,000**	**≤50**	**≤10,000**	**≤200**		**≤1,000; ≤10,000**
Fecal coliforms (cfu/100ml)					**≤1,000**	
***Legionella* sp. (cfu/l)[(a)]**	**≤1,000**					
***Salmonella* sp.**						**absence[(d)]**
Intestinal helminth eggs (eggs/l)	**≤1[(b)]**	**absence**			**≤0.1**	**≤0.1**
***Taenia saginata* and *Taenia solium* (egg/l)**						**≤1[(b)]**
TSS (mg/l)	**(c)**	**≤10**	**(c)**	**(c)**	**≤60**	**≤35**
BOD_5 (mg/l)	**(c)**	**≤10**	**(c)**	**(c)**		
COD (mg/l)		**≤70**				
Validation monitoring						
Fecal enterococci (log_{10} reduction)			**≥3**			
F-specific RNA bacteriophages (log_{10} reduction)			**≥3**			

Analytical parameters/ Category of use	JRC	Cyprus	France	Greece	Portugal	Spain
Sulphite-reducing bacteria spores (log_{10} reduction)			≥3			

less stringent than JRC   more stringent than JRC

(a): Only if there is risk of aerosolization. (b): When irrigation of pastures or fodder for livestock. (c): According to Directive 91/271/EEC.
(d): after certain monitoring results is compulsory to conduct analysis of *Salmonella*.
JRC: 90% samples, maximum value in 10% samples. Cyprus: 80% of the samples. Greece: median. Italy: 80% samples. Spain: 90% samples, maximum value in 10% samples.

The requirements of this Category 2 (Table 2) are to be applied for the irrigation of food crops consumed raw where the edible portion is produced above ground and is not in direct contact with reclaimed water, processed food crops, and non-food crops including crops to feed milk-or meat-producing animals. All irrigation methods are allowed. The exceptions are the following: Greece does not allow the use of sprinkler irrigation for this category, France only allows irrigation of cut flowers by drip irrigation within this category.

Table 3. Category of reclaimed water quality for agricultural irrigation in MS standards and the minimum quality requirements proposed by JRC.

Analytical parameters/ Category of use	JRC	Cyprus	France	Portugal	Spain
CATEGORY C					
Verification monitoring					
Escherichia coli **(cfu/100ml)**	≤1,000; ≤10,000	≤200	≤100,000		≤10,000; ≤100,000
Fecal coliforms (cfu/100ml)				≤10,000	
Legionella **sp. (cfu/l)**[(a)]	≤1,000				≤100
Intestinal helminth eggs (eggs/l)	≤1[(b)]	absence		≤0.1	≤0.1
TSS (mg/l)	(c)	≤35	(c)	≤60	≤35
BOD_5 (mg/l)	(c)	≤25	(c)		
COD (mg/l)		≤125			
Validation monitoring					
Fecal enterococci (log_{10} reduction)			≥2		
F-specific RNA bacteriophages (log_{10} reduction)			≥2		
Sulphite-reducing bacteria spores (log_{10} reduction)			≥2		

less stringent than JRC   more stringent than JRC

(a): Only if there is risk of aerosolization. (b): When irrigation of pastures or fodder for livestock. (c): According to Directive 91/271/EEC.
JRC: 90% samples, maximum value in 10% samples. Cyprus: 80% of the samples. Greece: median. Italy: 80% samples; maximum value. Spain: 90% samples, maximum value in 10% samples.

The requirements of this Category 3 (Table 3) are to be applied for the irrigation of processed food crops and non-food crops using only drip irrigation, and industrial, energy and seeded crops using all irrigation methods. It has to be noticed that Cyprus and Portugal allow all type of irrigation methods, while France only allows the irrigation of orchards, ornamental flowers, fodder, and cereals but all these food crops have to be irrigated only by drip irrigation. Spain allows the irrigation of orchards, ornamental flowers, nurseries and greenhouses only by drip irrigation.

Table 4. Category of the minimum quality requirements for agricultural irrigation proposed by JRC.

Analytical parameters/ Category of use	JRC
CATEGORY D	
Escherichia coli **(cfu/100ml)**	**≤10,000**
Legionella **sp. (cfu/l)[a]**	**≤1,000**
Sulphite-reducing bacteria spores (log_{10} reduction)	
Intestinal helminth eggs (eggs/l)	**≤1[b]**
F-specific RNA bacteriophages (log_{10} reduction)	
TSS (mg/l)	**(b)**
BOD_5 (mg/l)	**(b)**
COD (mg/l)	

(a): Only if there is risk of aerosolization. (b): According to Directive 91/271/EEC.
JRC: 90% samples, maximum 100,000 in 10% samples.

The requirements of this Category 4 (Table 4) are to be applied for the irrigation of industrial, energy and seeded crops with all irrigation methods allowed.

The risk management framework is not mentioned in the MS regulations as a tool to be applied by MS. But some elements of the RMF are sometimes included (Table 5). Supplementary physico-chemical parameters appear in some MS regulations, mainly agronomic parameters, while the minimum quality requirements proposed are recommending the application of a risk assessment according to local conditions to derived additional requirements for monitoring (Table 5).

Justification for the selected minimum quality requirements with references to MS regulations/guidelines are provided in the technical report (section 4.4).

Table 5. Additional requirements included in MS standards and in the proposed minimum requirements for water reuse in agricultural irrigation.

	JRC	Cyprus	France	Greece	Italy	Portugal	Spain
ALL CATEGORIES							
Application of elements from a risk management framework	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**Yes**
Elements applied	All elements	Multiple barrier	Multiple barrier, validation monitoring	Multiple barrier		Multiple barrier	Multiple barrier
Additional physico-chemical parameters and limit values	Depending on risk assessment results	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**Yes**
Parameters		Heavy metals, nutrients		Heavy metals, nutrients, organic substances	Heavy metals, nutrients, organic substances	Heavy metals, nutrients, organic substances	Heavy metals, nutrients

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IMPACT ASSESSMENT

Accompanying the document

Proposal for a Regulation of the European Parliament and of the Council on minimum requirements for water reuse

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Annex 7 - JRC Technical Report on the development of minimum quality requirements for water reuse in agricultural irrigation and aquifer proposed

Minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge

Towards a legal instrument on water reuse at EU level

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Title Minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge

Abstract
As an input to the design of a Legal Instrument on Water Reuse in Europe, this report recommends minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge based on a risk management approach.

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Contents

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Executive summary

At present, the uptake of water reuse solutions remains limited in comparison with their potential, which remains largely untapped. In the 2015 Communication '*Closing the loop – An EU action plan for the Circular Economy*' (COM/2015/614) and in the Inception Impact Assessment of the EU, water reuse initiative at hand, agricultural irrigation and aquifer recharge were identified as main potential sources of demand for reclaimed water. This is because both applications have the greatest potential in terms of its higher uptake, scarcity alleviation and EU relevance: agricultural irrigation as the biggest user of treated wastewater and the links with the Internal Market and aquifer recharge due to the cross-border nature of many aquifers. A primary goal is hence 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. As an input to the design of an EU Legal Instrument aiming at these two water reuse applications, this report recommends minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge based on a risk management approach.

Policy context

This report provides the scientific support for the development of a Legal Instrument on minimum quality requirements for water reuse at EU level for two specific uses, agricultural irrigation and aquifer recharge. This document has been requested by DG ENV and developed with additional inputs from experts in the water reuse field.

The opportunity to take action at EU level with a view to increasing water reuse was already identified in the 2012 Commission Communication "*A Blueprint to Safeguard Europe's Water Resources*" (COM(2012)673). This initiative would contribute to the achievements of some key objectives under the 7th EU Environment Action Programme to 2020 (i.e. protecting, conserving and enhancing the Union's natural capital and turning the Union into a resource-efficient economy). In the Communication "*Closing the loop – An EU action plan for the circular economy*" (COM(2015)614), the Commission already committed to develop a series of non-regulatory actions to promote safe and cost-effective water reuse. The Commission published in April 2016 an Inception Impact Assessment on "*Minimum quality requirements for reused water in the EU (new EU legislation)*" stating that the initiative of a regulation on minimum quality requirements for reused water in agricultural irrigation and aquifer recharge will encourage efficient resource use and reduce pressures on the water environment, provide clarity, coherence and predictability to market operators, and complement the existing EU water policy, notably the Water Framework Directive and the Urban Wastewater Treatment Directive.

The intention to address water reuse with a new legislative proposal was noted with interest by the Council in its conclusions on Sustainable Water Management (11902/16). Furthermore, the European Parliament, in its Resolution on the follow-up to the European Citizens' Initiative Right2Water in September 2015, encouraged the Commission to draw up a legislative framework on water reuse, as well as the Committee of the Regions, in its opinion on "*Effective water management system: an approach to innovative solutions*" in December 2016.

Key conclusions

The development of minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge is based on a risk management framework, which is recommended to tackle health and environmental risks and assure a safe use of reclaimed water for agriculture and aquifer recharge. The minimum requirements defined here ensure an appropriate health and environmental protection and thus provide public confidence in reuse practices. This document will contribute to establish a common approach on 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 guidance on the application of a risk management framework is identified as a need to complement a future regulation on water reuse.

Main findings

The document recommends specific minimum requirements for reclaimed water quality taking into consideration the health and environmental risks related to water reuse practices.

A risk management framework has to be applied to water reuse systems to assure a safe use of reclaimed water for agriculture and aquifer recharge, following the World Health Organization recommendation. Therefore, the main elements to implement a risk management framework are established, including the steps to develop health and environmental risks assessments. The related EU legislation has been always considered when appropriate.

Minimum quality requirements including microbiological and physico-chemical parameters, associated limit values and monitoring frequencies are established for agricultural irrigation. Preventive measures to be adopted are also defined.

The Groundwater Directive is the overarching framework for aquifer recharge with reclaimed water, and this Directive is embedded in the risk management framework to be applied.

Flexibility is given to Member States to define more stringent limits and to assess risks considering site specific conditions, especially for environmental risks.

Related and future JRC work

The JRC report "*Water Reuse in Europe: Relevant guidelines, needs for and barriers to innovation. A synoptic overview*" is an antecedent to the present document, also related to the water reuse topic. JRC support to forthcoming guidance on water reuse may be expected as a follow-up from this report, as a complement to a future legal instrument on water reuse.

Quick guide

Water reuse is defined as the use of treated wastewater for beneficial use. Synonymous to water reuse are also water reclamation and water recycling. A risk management framework involves identifying and managing risks in a proactive way, being a dynamic and practical system that, applied to water reuse, incorporates the concept of producing reclaimed water of a quality that is '*fit-for-purpose*'. It is also a systematic management tool that consistently ensures the safety and acceptability of water reuse practices. A central feature is that it is sufficiently flexible to be applied to all types of water reuse systems.

1 Introduction

More and more Europe's water resources are increasingly coming under stress, leading to water scarcity and quality deterioration. Pressures from climate change, droughts and urban development have put a significant strain on freshwater supplies (EEA, 2012). In this context, Europe's ability to respond to the increasing risks to water resources could be enhanced by a wider reuse of treated wastewater. As stated in COM (2015)614: "*Closing the loop – An EU action plan for the circular economy*" the Commission will take a series of actions to promote the reuse of treated wastewaters, including development of a regulatory instrument on minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge.

Information sources agree on the significant potential for further development of water reuse projects in the EU (BIO, 2015). Water reuse can help lower the pressure on freshwater resources. Other benefits include decreasing wastewater discharges, even if sometimes, during the summer period, the discharges are needed to achieve the ecological flow, and reducing and preventing pollution of surface water. In addition, development of reuse in the EU is a market opportunity for the water industry and other industries with a strong eco-innovation potential in terms of technologies and services around water recycling in industry, agriculture and domestic water systems. It will provide new and significant opportunities for Europe to become a global market leader in water-related innovation and technology.

Water reuse needs to be considered as a measure within the context of the water policy hierarchy. The EC Communication on Water Scarcity and Droughts (COM (2007)414) sets out the water hierarchy of measures that Member States (MS) should consider in managing water scarcity and droughts. This communication states that water saving must become the priority and all possibilities to improve water efficiency must therefore be explored. Policy making should be based on a clear water hierarchy. Additional water supply infrastructures should be considered as an option when other options have been exhausted, including effective water pricing policy and cost-effective alternatives. Water uses should also be prioritised: it is clear that public water supply should always be the overriding priority to ensure access to adequate water provision. It also states that in regions where all prevention measures have been implemented according to the water hierarchy (from water saving to water pricing policy and alternative solutions) and taking due account of the cost-benefit dimension, and where demand still exceeds water availability, additional water supply infrastructure can in some circumstances be identified as a possible other way of mitigating the impacts of severe drought.

Although the use of reclaimed water is an accepted practice in several EU countries experiencing water scarcity issues (e.g. Cyprus, Greece, Italy, Malta, Portugal, Spain), where it has become a component of long-term water resources management, overall a small proportion of reclaimed water is currently reused in the EU, even in those countries. Hence, there is significant potential for increased uptake of water reuse solutions in countries with several regions of water scarcity (Hochstrat *et al.*, 2005).

One of the main barriers identified is the lack of harmonization in the regulatory framework to manage health and environmental risks related to water reuse at the EU level, and thus a lack of confidence in the health and environmental safety of water reuse practices.

The health and environmental safety conditions under which wastewater may be reused are not specifically regulated at the EU level. There are no guidelines, regulations or good management practices at European Union (EU) level on water quality for water reuse purposes. In the Water Framework Directive (WFD) (2000/60/EC), reuse of water is mentioned as one of the possible measures to achieve the Directive’s quality goals: Part B of Annex VI refers to reuse as one of the “*supplementary measures*” which Member States within each river basin district may choose to adopt as part of the programme of measures required under Article 11(4). Besides that, Article 12 (4) of the Urban Wastewater Treatment Directive (91/271/EEC) concerning the reuse of treated wastewater states that “*treated wastewater shall be reused whenever appropriate*”.

Even though the lack of common water reuse criteria at the EU level, several Member States (MS) have issued their own regulations, or guidelines for different water reuse applications. However, after an evaluation carried out by the EC on the water reuse standards of several MS it was concluded that there are important divergences among the different regulations regarding the permitted uses, the parameters to be monitored, and the limiting values allowed (JRC, 2014). This lack of harmonization among water reuse standards within the EU might create some trade barriers for agricultural goods irrigated with reclaimed water. Once on the common market, the level of safety in the producing MS may not be considered as sufficient by the importing countries.

The relevance of EU action on water reuse was identified in the Impact Assessment of the “*Blueprint to Safeguard Europe's Water Resources*” published in November 2012. The Blueprint made clear that one alternative supply option- water reuse for irrigation or industrial purposes- has emerged as an issue requiring EU attention (COM(2012)673). Reuse of appropriately treated wastewater is considered to have a lower environmental impact than other alternative water supplies (e.g. water transfers or desalination), but it is only used to a limited extent in the EU. This appears to be due to the lack of common EU environmental/health standards for water reuse and the potential obstacles to the free movement of agricultural products irrigated with reclaimed water (COM(2012)673).

After the 2015 Communication “*Closing the loop - An EU action plan for the Circular Economy*” the Commission published in April 2016 an Inception Impact Assessment on “*Minimum quality requirements for reused water in the EU (new EU legislation)*” stating that the initiative of a regulation on minimum quality requirements for reused water in agricultural irrigation and aquifer recharge will encourage efficient resource use and reduce pressures on the water environment, provide clarity, coherence and predictability to market operators, and complement the existing EU water policy, notably the Water Framework Directive and the Urban Wastewater Treatment Directive.

To support this initiative the EC (DG ENV) asked its science and knowledge service, the Joint Research Centre (JRC) to develop a technical proposal for the minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge.

Considering the sensitivity of the health and environmental issue and public confidence in water reuse practice, the scientific advice of the independent Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) and the European Food Safety Authority (EFSA) has been be requested and taken into consideration in the final document.

2 Scope of the document

The purpose of this document is to propose minimum quality requirements for water reuse for two specific water reuse applications: agricultural irrigation and aquifer recharge. These requirements should ensure appropriate health and environmental protection and thus provide public confidence in reuse practices in order to enhance water reuse at EU level. This technical document is expected to support the proposal of EU legislation on water reuse.

The only source of wastewater considered in this document is the urban wastewater covered by Directive 91/271/EEC (Urban Wastewater Treatment Directive UWWTD) where urban wastewater is defined as domestic wastewater or the mixture of domestic wastewater with industrial wastewater and/or run-off rain water. The industrial wastewater considered is from the industrial sectors listed in Annex III of the UWWTD, which are the following:

- Milk-processing
- Manufacture of fruit and vegetables products
- Manufacture and bottling of soft drinks
- Potato-processing
- Meat industry
- Breweries
- Production of alcohol and alcoholic beverages
- Manufacture of animal feed from plant products
- Manufacture of gelatin and of glue from hides, skin and bones
- Malt-houses
- Fish-processing industry

This document does not deal with reclaimed water from other industrial sources: industrial wastewaters may have very particular characteristics in relation to quality and they may require specific quality criteria.

A **water reuse system**, as defined in this document, includes the following:

- Raw wastewater entering the wastewater treatment plant (WWTP)
- The wastewater treatment technologies included in the WWTP
- The additional treatments to produce reclaimed water of the required quality for reuse
- The storage and distribution systems
- The irrigation system (in case of agricultural irrigation), or the recharge method (in case of managed aquifer recharge)

For the purposes of developing the present work, a review of the available scientific, technical and legal knowledge on water reuse in agricultural irrigation and aquifer recharge has been carried out. Specifically, the documents that have been the basis to establish the minimum quality requirements for agricultural irrigation and aquifer recharge are the following:

- The regulatory framework at EU level on health and environmental protection

- The MS water reuse legislations and guidelines in place, along with their experience in water reuse systems
- Worldwide reference guidelines and regulations on water reuse
- Additional scientific references considered relevant for the topic

Selected experts in water reuse, whose contributions are gratefully acknowledged, have been consulted to provide comments and input through critical discussion on the document along the process. However, the content of this document has not been endorsed by these experts and reflects only the scientific opinion of the JRC. It is important to note that no risk assessment specifically for the establishment of the minimum quality requirements has been performed.

3 Framework for water reuse management

The approach to develop minimum quality requirements for the safe use of reclaimed water for agricultural irrigation and aquifer recharge is a **risk management framework**, as recommended by the World Health Organization WHO (WHO, 2006) and included in the Directive 2015/1787 that amends Directive 98/83/EC on the quality of water intended for human consumption.
The WHO, in order to tackle the health and environmental risks caused by microbiological and chemical contaminants potentially present in water, recommends to implement the principles of a risk management framework (WHO, 2001). The WHO suggests that a risk management approach should be applied to drinking water, reclaimed water, and recreational water. A risk management approach provides the conceptual framework for the WHO Guidelines for Drinking Water Quality (WHO, 2004 and 2011), and the Guidelines for the Safe use of Wastewater, Excreta and Greywater (WHO, 2006). A risk management approach involves identifying and managing risks in a proactive way, rather than simply reacting when problems arise being a dynamic and practical system that, applied to water reuse, incorporates the concept of producing reclaimed water of a quality that is 'fit-for-purpose'.

The Guidelines for the Safe Use of Wastewater, Excreta and Greywater (WHO, 2006) are divided into four volumes, devoted to different topics: Volume I, Policy and regulatory aspects; Volume II, Wastewater use in agriculture; Volume III, Wastewater and excreta use in aquaculture; and Volume IV, Excreta and greywater use in agriculture.
Following the risk management approach, the Australian government developed the Australian Guidelines for Water Recycling and the Australian Drinking Water Guidelines (NHMRC-NRMMC, 2011). The Australian Guidelines for Water Recycling provide a generic framework for management of reclaimed water quality and use that applies to all combinations of reclaimed water and end uses, including agricultural irrigation and aquifer recharge. These guidelines are structured in two phases. Phase I document (NRMMC-EPHC-AHMC, 2006) provides the scientific basis to assist and manage health and environmental risks. The three Phase II documents cover the specialized requirements for augmentation of drinking water supplies (NRMMC-EPHC-NHMRC, 2008), storm water harvesting and reuse, and managed aquifer recharge (NRMMC-EPHC–NHMRC, 2009). It is to note that the Australian Guidelines for Water Recycling are currently under a review that will draw on the advances and implementation of water recycling schemes.
The comprehensive risk management approach in the WHO Guidelines for Drinking Water Quality is termed "Water Safety Plan (WSP)" (WHO, 2009). The elements of a WSP build on many of the principles and concepts from other systematic risk management approaches, in particular the multiple-barrier approach and the hazard analysis and critical control points (HACCP) system (WHO, 2011). The WHO, and also the Australian guidelines, recommends the implementation of a risk management plan including a risk assessment for water reuse systems. For this purpose, the WHO has launched a Sanitation Safety Planning (SSP) manual as guidance on implementation of the WHO guidelines for water reuse (WHO, 2015). A SSP is a step-by-step health risk based approach for managing, monitoring and improving sanitation systems. The SSP is in line with the concept of the WSPs manual issued for drinking water supply systems (WHO, 2009).
The United States Environmental Protection Agency (USEPA) issued, in 2012, the last version of the Guidelines for Water Reuse (USEPA, 2012). These guidelines include a wide range of reuse applications (e.g. agricultural irrigation and aquifer recharge) and apply a

similar approach as described in the WHO and the Australian guidelines for controlling health and environmental risks.
In 2015, the International Organization for Standardization (ISO) published the Guidelines for treated wastewater use for irrigation projects, including agricultural irrigation (ISO 16075, 2015). These ISO guidelines provide guidance for healthy, environmentally and hydrologically good operation, monitoring, and maintenance of water reuse projects for unrestricted and restricted irrigation of agricultural crops, gardens, and landscape areas using treated wastewater. The guidelines are divided into four parts: The basis of a reuse project for irrigation, that considers climate, soils, design, materials, construction, and performance (Part 1); Development of the project (Part 2) that includes water quality requirements like microbiological and chemical parameters, potential barriers and potential corresponding water treatments; and Components of a reuse project for irrigation (Part 3) that includes recommendations for irrigation systems, and distribution and storage facilities, and Monitoring (Part 4). The ISO guidelines include recommended parameters and limit values that are elaborated on the basis of international regulations, like the WHO and the USEPA guidelines, to assure health and environmental safety of water reuse projects in irrigation.

The State of California has been a pioneer in issuing water reuse regulations and the water quality requirements that California establishes have become a global benchmark, and they have provided a basis for the development of water reuse regulations worldwide. The State of California regulatory approach on water reuse is based on stringent treatment technology targets with specific performance requirements for several uses, including also agricultural irrigation. Statutes and regulations related to water reuse in California are based on a risk assessment and the multiple-barrier principle and are included in the California Health and Safety Code, the California Water Code, and the California Code of Regulations. In the last update of the water reuse regulations, the Division of Drinking Water (DDW) (formerly known as CDPH) included also indirect potable reuse considering aquifer replenishment by surface and subsurface application (CDPH, 2014).

In EU countries, the most comprehensive water reuse regulations and recommendations issued by MS (i.e. Cyprus, France, Greece, Italy, Portugal, Spain) (DM, 2003; NP, 2005; RD, 2007; CMD, 2011; JORF, 2014; KDP, 2015) are based on the referenced guidelines and regulations cited above, all of them including several modifications for some uses (Paranychianakis *et al.*, 2014).

A **risk management framework** is a systematic management tool that consistently ensures the safety and acceptability of water reuse practices. A central feature is that it is sufficiently flexible to be applied to all types of water reuse systems, irrespective of size and complexity.
The risk management framework incorporates several interrelated elements, each of which supports the effectiveness of the others. Because most problems associated with reclaimed water schemes are attributable to a combination of factors, these factors need to be addressed together to ensure a safe and sustainable supply of reclaimed water. The elements, based on the recommendations of international guidelines (WHO, 2004, 2009 and 2011; NRMMC-EPHC-AHMC, 2006) are the following:

- Assembly of a risk management team.
- Description of the water reuse system.
- Identification of hazards and hazardous events, and risk assessment.

— Determination of preventive measures to limit risks.

— Development of operational procedures.

— Verification of the water quality and the receiving environment.

— Validation of processes and procedures.

— Management of incidents and emergencies.

In this context, it is of paramount importance that MS apply the principles of a risk management framework for the safe use of reclaimed water for agricultural irrigation and aquifer recharge.

4 Management of health and environmental risks for water reuse in agricultural irrigation

This section includes the definition of the key elements of a risk management framework that MS have to apply to manage health and environmental risks when reclaimed water is used in agricultural irrigation. It also includes the definition of common (not site specific) minimum quality requirements and preventive measures to be applied to all EU water reuse projects for agricultural irrigation, with the associated justification.

Regarding the source of wastewater to be reclaimed, as a minimum requirement, it has to be stressed that the Directive 91/271/EEC (UWWTD) that concerns the collection, treatment and discharge of urban wastewater, establishes quality requirements that have to be satisfied by discharges from urban wastewater treatment plants (UWWTP) including also specific requirements for discharges in sensitive areas (Annex I of UWWTD). Water from wastewater treatment plants destined for reuse is considered a discharge under the UWWTD at the point where it leaves the water treatment plant (after treatment) (EC, 2016). Therefore, as the only source of wastewater considered in this document is the wastewater covered by the UWWTD, all treated wastewater potentially considered for reclamation and reuse (i.e. wastewater coming from an UWWTP) has to comply, **at least**, with the quality requirements specified in the UWWTD Annex I, table 1 and, when applicable, with the requirements from Annex I, table 2 for sensitive areas.
In order to assure that wastewater that enter a UWWTP is included in the Annex III of the Directive 91/271/EEC, thus, it is necessary to establish source control programs and oversight of industrial and commercial discharges to the sewer systems connected to a wastewater treatment plant.

4.1 Agricultural irrigation uses

Agricultural irrigation is defined in this document as irrigation of the following types of crops:

- Food crops consumed raw: crops which are intended for human consumption to be eaten raw or unprocessed.
- 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).
- Non-food crops: crops which are not intended for human consumption (e.g. pastures, forage, fiber, ornamental, seed, energy and turf crops).

These definitions are based on the categories of use described in water reuse guidelines and some MS legislations (NRMMC-EPHC-AMHC, 2006; WHO, 2006; USEPA, 2012; JRC, 2014). Definitions included in EC food safety regulations 178/2002 and 852/2004 also apply to these classification.

4.2 Risk management framework for agricultural irrigation

It is recommended that MS have to apply the following elements of a risk management framework to manage health and environmental risks derived from the use of reclaimed water for agricultural irrigation.

4.2.1 Assembly of a risk management team

This step involves assembling a multidisciplinary team of individuals with adequate experience and expertise in protecting public and environmental health that understands the components of the water reuse system and is well placed to assess the associated risks.

4.2.2 Description of the water reuse system

The aim of this element is to provide a detailed understanding of the entire water reuse system from source to end use. A definition of a water reuse system is provided in Section 2. It is necessary to assess the historical water quality data, taking into account the variability, and to construct a flow diagram of the water reuse system from the source to the application or receiving environments.

4.2.3 Identification of hazards and hazardous events, and risk assessment

This element involves identifying all hazards and hazardous events of the water reuse scheme, and assessing the level of risk they pose to health and the environment.
Risk assessment can be defined as a characterization and estimation of potential adverse effects on health and environmental matrices associated with the intended use of reclaimed water. Different approaches to risk assessment are proposed in water reuse guidelines with varying degrees of complexity and data requirements. The risk assessment process can involve a quantitative or semi-quantitative approach, comprising estimation of likelihood/frequency and severity/consequence, or a qualitative approach (NRMMC–EPHC–AHMC, 2006; WHO, 2009 and 2015).

4.2.3.1 Health risks

Minimum quality requirements for the safety of human and animal health when crops are irrigated with reclaimed water, derived following a human health risk assessment, and considering animal health protection, are defined in Section 4.3 to be applied to all EU water reuse projects for agricultural irrigation independently of the site specific conditions.
Additional microbiological or physico-chemical parameters may be included as quality requirements by MS after a health risk assessment has been performed to justify this modification. Guidance on health risk assessment to be performed by MS is given below.
Health risk assessment includes the following steps:

— **Hazard identification:** identification of hazards that might be present in wastewater and the associated adverse effects to health.

  Health hazards to be considered are associated with the agricultural uses, thus including human and animal health.

  Biological (pathogens) and chemical hazards are to be assessed. Therefore, a characterization of the reclaimed water to be used for irrigation has to be performed to identify the concentrations of the health hazards present. Variations in hazards concentration are to be considered. Historical data may be of additional use to establish the concentration variation of a specific hazard.

— **Dose-response**: establishment of the relationship between the dose of the hazard and the incidence or likelihood of illness.

A dose-response model specific for each of the pathogens selected as a risk has to be used, based on the scientific knowledge (e.g. Haas *et al.*, 1999; Messner *et al.*, 2001; Teunis *et al.*, 2008).

Chemical compounds are evaluated by defining the NOAEL (*No Observed Adverse Effect Level*), the LOAEL (*Lowest Observed Adverse Effect Level*), and the RfD (*Reference Dose*) according to scientific knowledge.

— **Exposure assessment:** determination of the size and nature of the population exposed to the hazard, and the route, amount and duration of exposure.

  The route of exposure, exposure volumes and frequency of exposure of the hazards has to be defined considering local conditions. Scientific knowledge is limited, thus some conservative values are sometimes use, if no other data is available in the literature (NRMMC-EPHC-AHMC, 2006; WHO, 2006).

— **Risk characterisation:** integration of data on hazard presence, dose-response and exposure obtained in the first three steps.

  The tolerable health risk defined in this document is 10^{-6} DALYs per person per year. For microbiological hazards, performance targets for the reference pathogens selected and water quality targets for indicator organisms are to be determined as health-based targets. For chemical hazards, most frequently, health-based targets are water quality targets, taking the form of chemical guideline values. A chemical guideline value is the concentration of a chemical component that, over a lifetime of consumption, will not lead to more than 10^{-6} DALYs per person per year.

  The WHO performed a health risk assessment to derive maximum concentrations in soils for a set of organic and inorganic chemicals based on human health risks (WHO, 2006) and this data may be taken as a guidance if no updated scientific data is available.

4.2.3.2 Environmental risks

It is recommended that MS have to assure that the use of reclaimed water for agricultural irrigation has no adverse effects on environmental matrices (soil, groundwater, surface water, and dependent ecosystems, including crops to be irrigated) and that reclaimed water use is in compliance with the related EU directives for environmental protection.
Regulatory requirements of related EU Directives for environmental protection have to be always fulfilled. MS have to ensure that water reuse system does not compromise the objectives for surface water, groundwater, and dependent ecosystems established by the following EU directives:

— Directive 2000/60/EC (Water Framework Directive (WFD)).

— Directive 2008/105/EC (Environmental Quality Standards Directive (EQSD)) amended by Directive 2013/39/EU.

— Directive 2006/118/EC amended by Directive 2014/80/EE (Groundwater Directive (GWD)).

— Directive 91/271/EEC (Urban Wastewater Treatment Directive (UWWTD)).

— Directive 91/676/EEC (Nitrates Directive).

— Other related EU Directives that may apply.

In order to comply with these EU directives, MS have to establish, on a case-by-case basis, minimum quality requirements for parameters included in the related EU directives to be complied with by the reclaimed water effluent and to be included for verification monitoring. The guidance documents produced by the Common Implementation Strategy (CIS) of the WFD to assist MS to implement the WFD are to be use as tools to characterize the existent quality status of the surface water, groundwater, and related ecosystems that may be affected by reclaimed water used for irrigation. Guidance documents are intended to provide an overall methodological approach, but these will need to be tailored to specific circumstances of each MS.

Environmental risks related to nutrients from agricultural irrigation with reclaimed water are in great part to be controlled and reduced by MS through codes of good agricultural practices and Action Programmes established under the Nitrates Directive (91/676/EEC). These must contain, at least, provisions covering the items mentioned in Annex II and Annex III of the Directive including measures concerning balanced fertilization. The prevention of nitrate pollution via run-off from agricultural irrigation needs to be ensured especially in the designated Nitrate Vulnerable Zones.

In addition to the parameters of the related EU directives, other microbiological and physico-chemical hazards may also affect surface water, groundwater and dependent ecosystems according to the wastewater effluent to be treated for reuse, and the site specific conditions. Therefore, MS have to establish, according to the outcome of an environmental risk assessment, minimum quality requirements for additional parameters not included in the related EU Directives to be complied with by the reclaimed water effluent and to be included in the reclaimed water quality criteria.

Furthermore, MS have to perform an environmental risk assessment to protect soils, and dependent ecosystems, including crops to be irrigated, on a case-by-case basis according to site specific conditions, and establish, according to the outcome of the risk assessment, minimum quality requirements to be complied with by the final reclaimed water effluent and to be included in the reclaimed water quality criteria. Guidance on environmental risk assessment to be performed by MS is given below.

Environmental risk assessment includes the following steps:

— **Hazard identification:** identification of hazards that might be present in wastewater and the associated adverse effects to the environment.

  Environmental hazards are to be considered according to the environmental matrices that may be exposed to reclaimed water, which are soil, groundwater, surface water, and related biota (e.g. plants).

  The physico-chemical hazards to be evaluated for preventing adverse effects on **surface water, groundwater, and related ecosystems** are additional to the parameters defined in the related EU Directives mentioned above. The physico-chemical hazards also to be evaluated are hazards for preventing adverse effects on **soils, and related ecosystems** including **crops** (agronomic parameters) that include salinity related parameters, metals, nutrients, and trace elements. Indicative agronomic parameters are included in different guidelines (FAO, 1985; WHO, 2006; USEPA, 2012; ISO 16075, 2015).

— **Estimate the likelihood of a hazardous event:** estimate the likelihood that an environmental endpoint will be exposed to the hazard in sufficient concentrations to cause a detrimental effect.

Once the physico-chemical hazards concentrations are determined, it has to be established the likelihood that these concentrations will pose an adverse effect on the environmental matrices.

The concentrations of the agronomic parameters evaluated have to be assess to establish if they can have adverse effects on soils, crops and dependent ecosystems. For this purpose, soils and crops have to be characterized. Soil characterization includes the determination of the agronomic parameters, including texture, hydraulic conductivity, water retention capacity, and organic matter content. The specific crop requirements and toxicity to the physico-chemical hazards found in reclaimed water has to be evaluated in order to avoid phytotoxicity. Data related to crops and soils tolerance according to site specific conditions has to be used. Examples of limit values for agronomic parameters to protect soils and crops are also included in international guidelines (FAO, 1985; NRMMC-EPHC-AHMC, 2006; WHO, 2006; ISO 16075, 2015). The Directive 86/78/EEC (Sludge Directive) on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture establishes limit values for heavy metals in soils, and the maximum limit values of heavy metals amounts which may be added annually to agricultural land based on a 10 year average (Annex I A and C of Directive 86/78/EEC). These values may be taken into account as a reference in order to do not damage the soil quality. However, since the adoption of the Directive 86/78/EEC, several MS have enacted and implemented stricter limit values for heavy metals and set requirements for other contaminants. The Sludge Directive is now under a revision process and any update should be considered accordingly.

— **Estimate the consequences of the hazardous event:** determine the consequences (or impacts) of exposure to a hazard by considering the specific conditions of the environmental endpoint.

  If additional hazards to the ones considered in the EU related Directives to prevent adverse effects on surface water, groundwater, and dependent ecosystems are defined, it is necessary to estimate the adverse impact that these hazards may pose. This has to be established based on scientific knowledge.

  The consequences of the adverse effects to be posed to crops and soils by the agronomic parameters evaluated has to be determined based on scientific knowledge.

— **Characterize the overall risk:** characterize the risk by integrating the data on hazards, hazardous events, likelihood and consequences, obtained through the steps described above.

  The characterization of the overall risk has to be determined by combining the hazards and hazardous events with their likelihood and consequences. This can be done using a risk assessment matrix that rates risks from “low” to “very high”. An example of this procedure is found in the Australian guidelines (NRMMC-EPHC-AHMC, 2006).

  Based on the results obtained, MS have to establish water quality requirements to be included in the reclaimed water quality criteria, defining also possible preventive measures to be applied, as good agricultural practices.

4.2.4 Determination of preventive measures to limit risks

Safe use of reclaimed water requires the implementation of preventive measures (barriers) to reduce hazards and exposure to hazards by the following actions:

— Preventing hazards from entering reclaimed water.

— Removing them using treatment processes.

— Reducing exposure, either by using preventive measures at the site of use or by restricting uses.

Identification and implementation of preventive measures should be based on the multiple barrier principle. According to this principle, multiple preventive measures or barriers are used to control the risks posed by different hazards, thus making the process more reliable.

The strength of this principle is that a failure of one barrier may be compensated by effective operation of the remaining barriers, thus minimizing the likelihood of contaminants passing through the entire system and being present in sufficient amounts to cause any harm to human health or environmental matrices. Many control measures may contribute to control more than one hazard, whereas some hazards may require more than one control measure (WHO, 2011).

Water treatment processes prevent or reduce the concentration of hazards in the reclaimed water effluent and are the most important barrier to eliminate or minimize health and environmental risks of water reuse practices.

On-site controls are additional preventive measures that can prevent or minimise public exposure to hazards and can also minimise the impact on receiving environments.

The preventive measures that MS have to consider in order to reduce potential adverse effects on health and the environment, according to site specific conditions, are the following:

— **Wastewater treatment technologies**: treatment technologies are an essential barrier to prevent health and environmental risks. Untreated raw wastewater and secondary treated wastewater effluents (complying with UWWTD) are forbidden to be used directly for irrigation purposes. Therefore, an additional treatment is always needed in order to use urban wastewater for agricultural irrigation.

— **Crops characteristics**: the characteristics of crops (i.e. crops eaten raw, processed, with inedible skin) are taken into account as a barrier to reduce health risks to consumers. Selection of crops has to be made according to crop tolerance (e.g. salt and specific ion tolerance), reclaimed water quality and soil properties to produce satisfactory yields.

— **Irrigation method**: the different irrigation methods considered reflect the reduction in exposure to health hazards that specific irrigation methods present (i.e. drip irrigation) and the greater risks that other irrigation methods pose due to aerosols formation (i.e. sprinkler irrigation).

— **Drinking water sources protection**: the vulnerability of existing drinking water sources to the use of reclaimed water for irrigation has to be assessed. Article 7 of the WFD requires that MS shall ensure the necessary protection for waters used for the abstraction of drinking water, or intended for such use, with the aim of avoiding deterioration in their quality, establishing safeguard zones for those bodies of water, if necessary.

— **Control of the storage and distribution system**: within the distribution system, that may include storage (open and closed reservoirs), reclaimed water for irrigation may suffer changes that affect its chemical and biological quality (e.g. microbial regrowth, nitrification, algae growth, natural decay of microorganisms). Thus, management strategies, including monitoring, have to be undertaken in order to prevent the deterioration of reclaimed water quality. Maintaining good water quality in the distribution system will depend on the design and operation of the system and on maintenance and survey procedures to prevent contamination. Control of short-circuiting and prevention of stagnation in both storage and distribution, including use of backflow prevention devices, maintaining positive pressure throughout the system and implementation of efficient maintenance procedures are strategies to maintain the quality of reclaimed water within the storage and distribution system. Reclaimed water can be mixed with water from natural sources to correct for certain parameters.

— **Irrigation schedule**: reclaimed water application rates need to be controlled so that irrigation is consistent in providing maximum benefit, while minimising impacts on receiving environments (including soils, groundwater and surface water). Irrigation systems should be installed and operated to minimise surface ponding and to control surface run-off.

— **Access control, buffer zones (security distances) and withholding periods**: these measures should be established as necessary to minimize exposure to health hazards to humans and animals. It is needed to consider access control for on-site workers, general public, and animals, and define specific withholding periods for livestock to be fed with irrigated pastures or fodder.

  The establishment of access control, buffer zones (security distances) and withholding periods has to be evaluated considering the reclaimed water quality used, the irrigation method, and the site specific conditions (e.g. windy situations). On-site workers access should ensure compliance with related occupational health and safety regulations in place.

— **Education and training**: education and training of on-site workers and managers involved in agricultural irrigation are of principal importance as components of implementing and maintaining preventive measures. Personnel should be kept fully informed on the use of reclaimed water. Agricultural workers are especially vulnerable, and a range of human exposure measures (e.g. personal protective equipment, handwashing and personal hygiene) are also to be implemented. Occupational health related EU Directives and national regulations from MS should apply.

— **Signage**: accidental exposure to reclaimed water can be reduced through the use of measures such as signage at irrigation sites, indicating that reclaimed water is being used and is not suitable for drinking.

Recommendations for the assessment and implementation of these preventive measures in water reuse schemes for agricultural irrigation are included in the ISO guidelines (ISO 16075, 2015) and other water reuse guidelines (NRMMC-EPHC-AHMC, 2006; WHO, 2006; USEPA, 2012). However, MS must always consider site specific conditions for selection and implementation of preventive measures.

The selection of common preventive measures (barriers) already considered by this document to develop the common minimum quality requirements in Section 4.3 have been the wastewater treatment technology, the crops characteristics, the irrigation method and the withholding periods and access control for livestock.

4.2.5 Development of operational procedures

MS have to assure the appropriate performance of the water reuse system to deliver the requested level of reclaimed water quality. It is necessary to develop an operational monitoring protocol to define operational procedures for all activities and process applied within the **whole water reuse system** to ensure that all preventive measures implemented to control hazards are functioning effectively.
MS have to develop an operational monitoring protocol to assess and confirm that the performance of preventive measures of the water reuse system ensures reclaimed water of an appropriate quality to be consistently provided. A water reuse system in Section 2 of this document is defined as follow:

— Raw wastewater entering the wastewater treatment plant (WWTP).

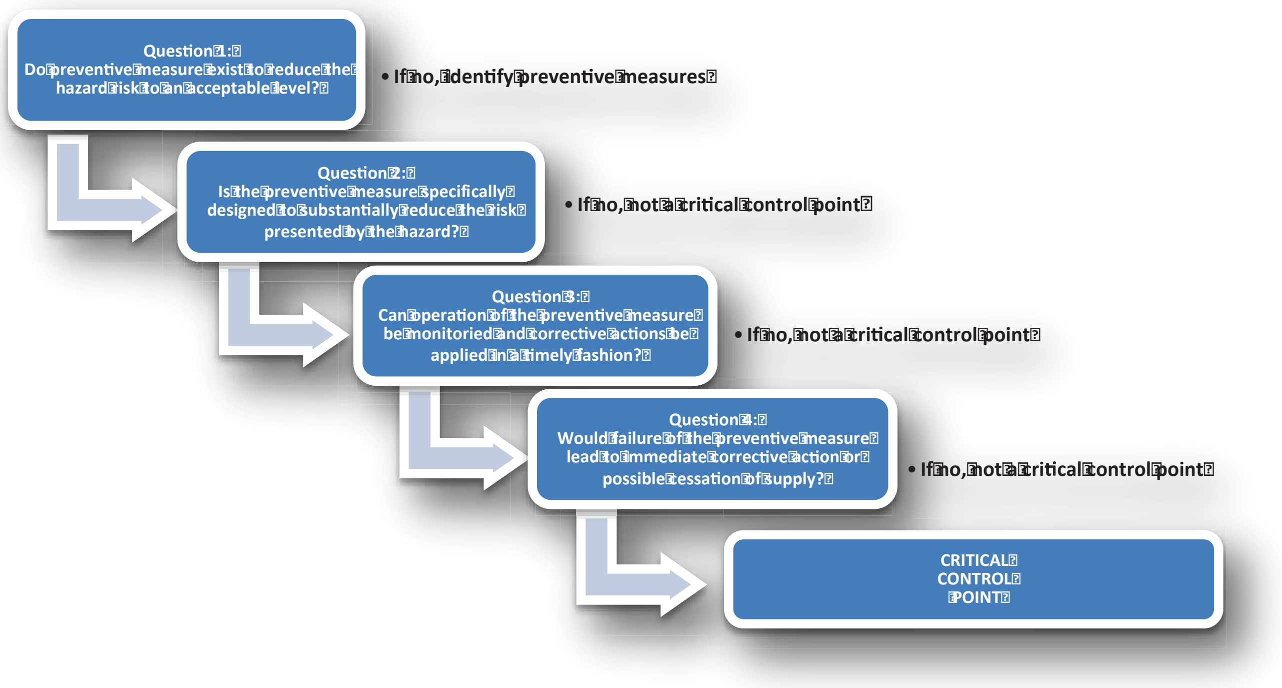
— The wastewater treatments included in the WWTP.

— The additional treatments to produce reclaimed water of the required quality for reuse.

— The storage and distribution systems.

— The irrigation system.

Figure 1. Decision support tree to identify critical control points in a water reuse system.



Source: JRC, 2014.

Critical control points of the water reuse system have to be determined as they are the focus of the operational monitoring. The identification of critical control points is system specific and it can be done by applying a decision tree shown in Figure 1.

The operational monitoring protocol has to include parameters that can be readily measured and provide an immediate indication of performance of the preventive measures to enable a rapid response (e.g. disinfectant residuals and other disinfection-related parameters). On-line monitoring with real-time data reporting is strongly recommended when technologically feasible (see informative Annex). Operational parameters have to be associated with target limits and critical limits to define effectiveness and detect variations in performance. Observational manual checking of preventive measures is also part of the operational monitoring.

Operational monitoring protocol has also to include procedures for corrective actions to be implemented when operational parameters are deviated from the critical limit. Operational monitoring protocols are described in several guidelines (NRMMC-EPHC-AHMC, 2006; WHO, 2006).

Examples of operational monitoring requirements for the preventive measure of wastewater treatment processes are shown in Table 1.

Table 1. Examples of operational monitoring for several treatment processes.

Treatment process	Operational monitoring	Indicative frequency
Secondary treatment (activated sludge)	Flow rate Nitrate, nitrites BOD_5 Suspended solids, solids retention time Dissolved oxygen Hydraulic retention time	Continuous (on-line) for flow rate, dissolved oxygen Weekly for other parameters
Low-rate biological systems (stabilization ponds)	Flow rate BOD_5, (facultative and maturation ponds) Algal levels	Continuous (on-line) for flow rate Weekly for other parameters
Soil-aquifer treatment	Flow rate Total Organic Carbon (TOC) Total Nitrogen, nitrates, nitrites	Continuous (on-line) Weekly for other parameters
Media filtration system	Flow rate Turbidity	Continuous (on-line)
Membrane bioreactor (MBR)	pH Turbidity Suspended solids, solids retention time Dissolved oxygen Hydraulic retention time Transmembrane pressure	Continuous (on-line) for parameters such as pH, turbidity, dissolved oxygen, transmembrane pressure Weekly for other parameters
Membrane filtration technology	Transmembrane pressure Turbidity Electrical conductivity	Continuous (on-line)
Ultraviolet light disinfection (UV)	Flow rate Turbidity upstream UV intensity and/or calculated dose UV transmissivity	Continuous (on-line)
Ozone/Biological Activated Carbon	Ozone dose Temperature	Continuous (on-line)
Chlorination	Free chlorine residual, Ct* pH Temperature	Continuous (on-line)

(*) Ct means the product of residual disinfectant content (mg/l) and disinfectant contact time (min).

Source: WHO, 2006; NRMMC-EPHC-AHMC, 2006; USEPA, 2012.

4.2.6 Verification of water quality and receiving environments

This element comprises verification of the overall performance of the water reuse treatment system, the ultimate quality of reclaimed water being supplied, and the quality of the receiving environment. Verification monitoring is the use of methods, procedures or tests, in addition to those used in operational monitoring, to assess the overall performance of the treatment system, the compliance with regulatory requirements of the ultimate quality of the reclaimed water being supplied, and the quality of the receiving environment.

MS have to perform a routine monitoring to verify that the reclaimed water effluent is complying with the requested quality criteria included in Section 4.3 and the additional quality requirements that MS decide to include as quality criteria derived from EU related Directives and risk assessment outcomes according to site specific conditions.

MS have to implement monitoring programs of the environmental matrices at risk to control the effect of reclaimed water irrigation as part of the verification monitoring. A monitoring program for soils, crops, groundwater and surface water, and dependent ecosystems has to be established, on a case-by-case basis, according to the identified risks. Recommendations for monitoring programs of environmental matrices when reclaimed water is used for agricultural irrigation are described in the ISO guidelines (ISO 16075, 2015).

Analytical methods used for monitoring shall comply with the requirements included in the related Directives (i.e. WFD (2000/60/EC), DWD (98/83/EC), GWD (2006/118/EC) to conform to the quality control principles, including, if relevant, ISO/CEN or national standardized methods, to ensure the provision of data of an equivalent scientific quality and comparability.

4.2.7 Validation of processes and procedures

Validation aims to ensure that processes and procedures control hazards effectively and that the water reuse system is capable of meeting its design requirements. One of the objectives of validation monitoring is to prove that the water reuse system can deliver the expected water quality specified for the intended use. Therefore, validation monitoring includes also operational and verification monitoring parameters, discussed above.

Validation monitoring has to be conducted when a reclamation system is established (commissioned) and put in operation, when equipment is upgraded or new equipment or processes are added. Once the setup of the whole water reuse system has been validated, it is generally sufficient with the operational and verification monitoring.

MS have to perform, as part of the validation monitoring, the requested performance targets defined in Table 5.

4.2.8 Management of incidents and emergencies

This element deals with responses to incidents or emergencies that can compromise the quality of reclaimed water. MS have to establish incident and emergency protocols, and to develop and document response plans. Such responses protect public and environmental health, and help to maintain user confidence in reclaimed water.

Following the aforementioned key principles for a risk management framework, minimum reclaimed water quality criteria and preventive measures to manage human and animal health risks from consuming crops irrigated with reclaimed water have been derived to be implemented to all water reuse projects at EU level. The justification for this selected requirements is presented in Section 4.4.

4.3 Minimum reclaimed water quality criteria and preventive measures

Following the aforementioned key principles for a risk management framework, minimum reclaimed water quality criteria and preventive measures to manage human and animal health risks from consuming crops irrigated with reclaimed water have been derived to be implemented to all water reuse projects at EU level. The justification for this selected requirements is presented in Section 4.4.

The reclaimed water quality criteria are defined in Table 2. The classes of reclaimed water quality, and the associated use according to the barriers considered is shown in Table 3. The frequencies for monitoring the final reclaimed water effluent are defined in Table 4.

Table 2. Reclaimed water quality criteria for agricultural irrigation.

Reclaimed water quality class	Indicative technology target	Quality criteria				
		E. coli (cfu/100 ml)	BOD_5 (mg/l)	TSS (mg/l)	Turbidity (NTU)	Additional criteria
Class A	Secondary treatment, filtration, and disinfection (advanced water treatments)	≤10 or below detection limit	≤10	≤10	≤5	*Legionella* spp.: ≤1,000 cfu/l when there is risk of aerosolization. Intestinal nematodes (helminth eggs): ≤1 egg/l when irrigation of pastures or fodder for livestock.
Class B	Secondary treatment, and disinfection	≤100	According to Directive 91/271/EEC	According to Directive 91/271/EEC	-	
Class C	Secondary treatment, and disinfection	≤1,000	According to Directive 91/271/EEC	According to Directive 91/271/EEC	-	
Class D	Secondary treatment, and disinfection	≤10,000	According to Directive 91/271/EEC	According to Directive 91/271/EEC	-	

Source: JRC analysis.

Table 3. Classes of reclaimed water quality, and the associated agricultural use and irrigation method considered.

Crop category	Minimum reclaimed water quality class	Irrigation method
All food crops, including root crops consumed raw and food crops where the edible portion is in direct contact with reclaimed water	Class A	All irrigation methods allowed

Crop category	Minimum reclaimed water quality class	Irrigation method
Food crops consumed raw where the edible portion is produced above ground and is not in direct contact with reclaimed water	Class B	All irrigation methods allowed
	Class C	Drip irrigation only
Processed food crops	Class B	All irrigation methods allowed
	Class C	Drip irrigation only
Non-food crops including crops to feed milk- or meat-producing animals	Class B	All irrigation methods allowed
	Class C	Drip irrigation only
Industrial, energy, and seeded crops	Class D	All irrigation methods allowed

Source: JRC analysis.

Table 4. Minimum frequencies for reclaimed water monitoring for agricultural irrigation.

	Minimum monitoring frequencies					
Reclaimed water quality classes	***E. coli***	**BOD_5**	**TSS**	**Turbidity**	***Legionella* spp. (when applicable)**	**Intestinal nematodes (when applicable)**
Class A	Once a week	Once a week	Once a week	Continuous	Once a week	Twice a month or frequency determined according to the number of eggs in wastewater.
Class B	Once a week	According to Directive 91/271/EEC	According to Directive 91/271/EEC	-		
Class C	Twice a month	According to Directive 91/271/EEC	According to Directive 91/271/EEC	-		
Class D	Twice a month	According to Directive 91/271/EEC	According to Directive 91/271/EEC	-		

Source: JRC analysis.

The reclaimed water quality criteria will be considered compliant with the requirements shown in Table 2 if the analytical controls meet all of the following criteria:

— Values for criteria of *E. coli* and *Legionella* and intestinal nematodes (Table 2) must be conformed at 90% of the samples. Samples cannot exceed the maximum deviation limit of 1 log unit from the indicated value for *E. coli* and *Legionella*, and 100% of the indicated value for intestinal nematodes.

— Values for criteria of BOD_5, TSS, and turbidity in Class A (Table 2) must be conformed at 90% of the samples. Samples cannot exceed the maximum deviation limit of twice the value defined in Table 2.

Reclaimed water must comply with the quality criteria at the outlet of the treatment plant. The reclaimed water has to follow the same procedures as for any other irrigation water source once the water is delivered to the final user. The European Commission notice on guidance document on addressing microbiological risks in fresh fruits and vegetables at primary production through good hygiene is a guidance document to be considered (Notice 2017/C 163/01).

MS have to perform a routine monitoring to verify that the reclaimed water effluent is complying with the requested quality criteria and to be included in the verification procedures of the water reuse system.

Validation monitoring is mandatory for MS for the most stringent reclaimed water quality class, Class A, which relies only on the treatment technologies in place to meet the minimum quality requirements. The Class A allows irrigation of food crops eaten raw even when the reclaimed water is in contact with the edible parts of the crop and root crops eaten raw. Validation for Class A is required to assess that the performance targets (log_{10} reduction) are complied with by the water reuse system. Validation monitoring entails the monitoring of the indicator microorganisms associated to each group of pathogens (bacteria, virus and protozoa). The indicator microorganisms selected are *E. coli* for pathogenic bacteria, F-specific coliphages, somatic coliphages or coliphages for pathogenic viruses, and *Clostridium perfringens* spores or spore-forming sulfate-reducing bacteria for protozoa. Performance targets and monitoring frequencies required are shown in Table 5.

It has to be noticed that the **reference pathogens** used to define the log removals (see section 4.4.4), *Campylobacter*, rotavirus and *Cryptosporidium*, can always be used for monitoring purposes instead of the proposed indicators.

Performance targets (log_{10} reduction targets) for the selected indicator microorganisms are to be met considering the concentrations of the raw wastewater effluent entering the UWWTP as the initial point, and the concentrations of the final reclaimed water effluent at the outlet of the additional treatment processes as the final point.

Validation monitoring has to be performed before the reuse scheme is put into place, when equipment is upgraded, and when new equipment or processes are added.

Table 5. Validation monitoring of the treatment performance for agricultural irrigation.

Reclaimed water quality class	Indicator microorganisms	Performance targets for the treatment train (log_{10} reduction)
Class A	*E. coli*	≥ 5.0
	Total coliphages/F-specific coliphages/ somatic coliphages*	≥ 6.0
	Clostridium perfringens spores/spore-forming sulphite-reducing bacteria**	≥ 5.0

(*)Total coliphages is selected as the most appropriate viral indicator. However, if analysis of total coliphages is not feasible, at least one of them (F-specific or somatic coliphages) has to be analyzed.
(**)*Clostridium perfringens* spores is selected as the most appropriate protozoa indicator. However, spore-forming sulfate-reducing bacteria is an alternative if the concentration of *Clostridium perfringens* spores does not allow to validate the requested log_{10} removal.
Source: JRC analysis.

Analytical methods used for monitoring shall comply with the requirements included in the related Directives (i.e. WFD (2000/60/EC), DWD (98/83/EC), GWD (2006/118/EC) to conform to the quality control principles, including, if relevant, ISO/CEN or national standardized methods, to ensure the provision of data of an equivalent scientific quality and comparability.

MS have to comply with common specific preventive measures for any water reuse project regardless of the site specific conditions (Table 6).

Table 6. Specific additional preventive measures for health protection to be complied with by MS for any site specific condition.

Reclaimed water quality class	Specific additional preventive measures to be complied with by MS
Class A	- Pigs must not be exposed to fodder irrigated with reclaimed water unless there is sufficient data to indicate the risks for a specific case can be managed.
Class B	- Prohibition of harvesting of wet irrigated or dropped produce. - Exclude lactating dairy cattle from pasture until pasture is dry. - Fodder has to be dried or ensiled before packaging. - Pigs must not be exposed to fodder irrigated with reclaimed water unless there is sufficient data to indicate the risks for a specific case can be managed.
Class C	- Prohibition of harvesting of wet irrigated or dropped produce. - Exclude grazing animals from pasture for five days after last irrigation. - Fodder has to be dried or ensiled before packaging. - Pigs must not be exposed to fodder irrigated with reclaimed water unless there is sufficient data to indicate the risks for a specific case can be managed.
Class D	- Prohibition of harvesting of wet irrigated or dropped produce.

Source: JRC analysis.

The reclaimed water quality requirements and preventive measures are an integral part of the risk management framework for water reuse in agriculture. It is clearly emerging that the more "site-specific" risks, which are mostly related to environmental issues, are handled either under the umbrella of the Water Framework Directive and its Daughter Directives or subject to the development of specific risk assessments considering local conditions.

4.4 Justification for the selected quality requirements

The quality requirements have been established following the risk management approach. This framework is recommended by the WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater (WHO, 2006) and it has been applied and further detailed in the Australian Guidelines for Water Recycling (NRMMC–EPHC–AHMC, 2006).

There was no specific risk assessment with European data performed for the present document to evaluate water reuse schemes for agricultural irrigation. The selection of the minimum quality requirements established is based on existing water reuse guidelines and MS regulations, and on the health and environmental risks considered by them.

The health and environmental risks related to water reuse in agricultural irrigation are associated to the potential presence of pathogens and physico-chemical constituents that may pose a risk to human and animal health, and to environmental matrices.

4.4.1 Health and environmental risks considered for agricultural irrigation

Health risks considered in this document are established based on the exposure scenarios recommended by WHO guidelines (WHO, 2006), which are the following:

- Ingestion of irrigated crops by consumers.
- Ingestion of droplets (produced by sprinkler irrigation) by workers, bystanders and residents in nearby communities.
- Inhalation of aerosols (produced by sprinkler irrigation) by workers, bystanders and residents in nearby communities.
- Dermal exposure by workers, bystanders and residents in nearby communities.
- Ingestion of soil particles by workers, bystanders and residents in nearby communities.
- Ingestion of pastures and fodder by milk- or meat-producing animals (human and animal health).
- Contamination of drinking water sources.

The environmental risks considered are based on the principle of no adverse effects to be caused to environmental matrices, according to their present status, in compliance with the related EU directives for environmental protection mentioned above. In complementarity, specific environmental risks assessments related to water reuse for agricultural irrigation established in different guidelines for the environmental matrices (soil, groundwater, surface water, plants, and dependent ecosystems) (WHO, 2006; NRMMC–EPHC–AHMC, 2006) have been also considered. These guidelines include risks of salinization, eutrophication, toxicity, and soil structure decline, among others.

4.4.2 Tolerable risk for human health

The definition of a tolerable risk as a health-outcome target is required by the risk management framework to develop the other health-based targets (performance targets and water quality targets).

Although the management of health risks is context specific, the WHO guidelines consider that the overall levels of health protection should be comparable for different water-related exposures (i.e. drinking water, reclaimed water irrigation of foods).

The WHO Guidelines for Drinking Water Quality (WHO, 2004 and 2011) establish the tolerable burden of disease (caused by either a chemical or an infectious agent) as an upper limit of 10^{-6} Disability Adjusted Life Years (DALYs) per person per year (pppy). This upper limit DALY is approximately equivalent to a 10^{-5} excess lifetime risk of cancer (i.e. 1 excess case of cancer per 100 000 people ingesting drinking-water at the water quality target daily over a lifetime that is used in the guidelines to determine guideline values for the maximum concentration of genotoxic carcinogens in drinking water), or an annual diarrhoeal risk of disease of 10^{-3} (i.e. one illness per 1000 people or 1 in 10 lifetime risk). These figures correspond closely to the 70-year lifetime waterborne cancer risk of 10^{-5} per person accepted by the USEPA (Mara, 2011). The tolerable burden of disease of 10^{-6} DALYs corresponds approximately to an infection risk of 10^{-3} ppy for rotavirus or *Cryptosporidium* and 10^{-4} ppy for *Campylobacter* (WHO, 2006; Mara, 2008).

In the context of reclaimed water use, since food crops irrigated with reclaimed water, specially those eaten uncooked, are also expected to be as safe as drinking water by those who eat them, the WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater (WHO, 2006) also recommend the same tolerable level of risk of 10^{-6} DALYs. The tolerable risk adopted in the Australian Guidelines for Water Recycling (NRMMC–EPHC–AHMC, 2006) is the same as the one selected by the WHO guidelines (WHO, 2006).

The 10^{-6} DALYs tolerable risk has been also selected for the Directive (98/83/EC) of water for human consumption (Drinking Water Directive (DWTD)) that considers as tolerable health risk a 10^{-5} excess lifetime risk of cancer, as recommended by the WHO.

The other often referred benchmark level of acceptable risk is the one defined by the USEPA that considers one infection per 10000 individuals in a given year ($\leq 10^{-4}$ pppy) as a reasonable level of safety for drinking water and also reclaimed water use (USEPA, 1989 and 2012). This number was derived in 1987 by determining the waterborne disease burden already tolerated in the United States. The USEPA does not use the DALYs metric, and the tolerable risk of infection selected can be considered similar to the WHO guidelines tolerable risk, although comparisons are difficult due to the assumptions applied to derive them.

It is important to notice that the current tolerable risk levels of WHO and USEPA guidelines have been questioned and they have been considered too stringent (Haas, 1996; Mara, 2011). Haas (1996) has said that it became apparent that some key factors used for computing of the 1:10,000 level of acceptable risk in USEPA guidelines may not be accurate thus considering that the current benchmark may be far too stringent. The computation of the currently used risk level from the late 1980s appears to have risen partly because, at that time, the perceived waterborne disease rate was 1 case per 10,000 people per year. But more recent assessments show that the actual burden of waterborne disease associated with water treatment practices appear to be much higher (Haas, 1996; Colford *et al.*, 2006). This would suggest that an annual risk of infection of 1 in 1,000, or even a less strict risk level, is more appropriate than the current approach. Mara (2011) states that the current maximal additional burden of disease (10^{-6} DALYs pppy) should be lowered to 10^{-4} DALYs pppy, based on a critical analysis of the basis from which the current benchmark is derived, the 70-lifetime waterborne cancer risk of 10^{-5} per person per year.

Therefore, in view of these considerations, the tolerable risk of **10^{-6} DALYs pppy** used in this document is considered safe enough to be applied at EU level.

4.4.3 Reference pathogens

Reference pathogens have been selected to be able to determine the performance targets ($\log_{10}$ reductions). It is impractical, and there are insufficient data, to set performance targets for all waterborne pathogens potentially present in wastewater, particularly since this would require information on concentrations, dose-response relationships, and disease burdens that is often not available. A more practical approach is to identify reference pathogens that represent groups of pathogens taking into account variations in characteristics, behaviours and susceptibilities of each group to different treatment processes. Typically, different reference pathogens will be identified to represent bacteria, viruses, protozoa and helminths (NRMMC-EPHC-AMHC, 2006; WHO, 2006; USEPA, 2012). It is to note that controlling reference pathogens implies controlling all pathogen risks that are covered by the reference pathogen.

The reference pathogens selected are the ones recommended by the WHO guidelines for water reuse and drinking water, which are *Campylobacter* for bacteria, rotavirus for viruses and *Cryptosporidium* for protozoa (WHO, 2006 and 2011). These are also the reference pathogens used by the DWD.

Campylobacter compared with other bacterial pathogens, has the infective dose relatively low and is relatively common, and waterborne outbreaks have been recorded. This selection is in agreement with the bacterial reference pathogens recommended by Australian guidelines for water reuse and drinking water (NRMMC–EPHC–AHMC, 2006; NHMRC-NRMMC, 2011).

Rotavirus is used as reference pathogen for pathogenic enteric viruses because they represent a major risk of viral gastroenteritis, they have a relatively high infectivity compared with other waterborne viruses and a dose-response model has been established (Havelaar and Melse, 2003). Adenoviruses have been detected in very high numbers in raw wastewater, and they appear to be the most resistant to water treatment technologies. Data gathered on rotavirus, norovirus and adenovirus indicated that prevalence in raw wastewater of these three viruses could be similar (NRMMC–EPHC–AHMC, 2006). Due to these considerations, the reference pathogen for pathogenic viruses selected by the Australian guidelines is an amalgam of rotavirus and adenovirus, using dose-response data for rotavirus and occurrence data for adenovirus.

Nevertheless, the use of rotavirus has been complicated by the development and use of a rotavirus vaccine that over time will change the incidence and severity of disease outcomes from this pathogen (Gibney *et al.*, 2014). On this basis, norovirus seems that it would be selected instead of rotavirus in the future potable reuse WHO guidelines and the future new revision of the Australian guidelines as reference pathogen. A dose response model has been published for norovirus (Teunis *et al.*, 2008) and a disease burden has been determined (Gibney *et al.*, 2014). However, these risk assessments are not published yet and there is no evidence that these considerations would change the final $\log_{10}$ reduction requested for viruses applied by the Australian guidelines.

Cryptosporidium is reasonably infective (Teunis *et al.*, 2002), is resistant to chlorination and is one of the most important waterborne human pathogens in developed countries (NRMMC–EPHC–AHMC, 2016). Although *Giardia* may be another candidate, as it is typically present in raw wastewater at some 10–100 times the concentration of *Cryptosporidium* (Yates and Gerba, 1998), and may be marginally more infective (Rose *et al.*, 1991), it is more readily removed by treatment processes and is more sensitive to most types of disinfection than *Cryptosporidium* (NRMMC–EPHC–AHMC, 2016). Therefore, *Cryptosporidium* is preferred as the reference pathogen for protozoa. This selection is also in agreement with the reference pathogens selected by the Australian guidelines for water reuse and drinking water (NRMMC–EPHC–AHMC, 2006; NHMRC-NRMMC, 2011).

It has not been selected a reference pathogen for helminths, since helminth infections are not endemic in EU countries, there is limited information on occurrence in water and there is no human dose-response model. However, for protection of human health, the protozoan reference pathogen can be used as a reference for helminths. Helminths are likely to be present in lower numbers than protozoa in sources of reclaimed water, and they will be removed more readily by physical treatment processes such as filtration and stabilization ponds as they are larger than protozoa (NRMMC–EPHC–AHMC, 2006).

4.4.4 Performance targets

No risk assessment has been performed specifically for this work, therefore, the performance targets have been established following the approach used by the Australian guidelines for water reuse practices (NRMMC–EPHC–AHMC, 2006) to establish performance and water quality targets. This approach consist on the translation of a tolerable risk level to performance targets. The Australian guidelines have been selected as the most appropriate scientific-based document to be used. They apply the tolerable risk of 10^{-6} DALYs pppy recommended by the WHO guidelines and considered safe enough for the development of the minimum quality requirements at EU level, and they also deploy the risk assessment carried out to derived the performance targets (log_{10} reductions) for human health risks control. Although there are some similarities with the log_{10} reductions defined by the WHO guidelines, it is considered that assumptions made by Australian guidelines reflect more accurately the situation in MS, also considering the fact that the WHO guidelines include assumptions from developing countries in the development of the risk assessment.

Pathogen concentration in raw wastewater can vary over a wide range, *Campylobacter* concentration can vary from 10^2 to 10^5 cfu/l, rotavirus can also vary from 10^2 to 10^5 pfu/l, and *Cryptosporidium* may vary between 0 and 10^4 oocysts/l according to several sources cited in Australian guidelines (NRMMC–EPHC–AHMC, 2006) which are in line with concentrations reported in WHO and EPA guidelines (WHO, 2006; EPA, 2012). Due to these variations, 95th percentiles are therefore used in determining the performance targets. The 95th percentiles of organisms per litre in raw wastewater used for the reference pathogens were 7000 for *Campylobacter*, 8000 for rotavirus and 2000 for *Cryptosporidium*. These concentrations are consistent with international data, according to Australian guidelines. The assumptions made to apply the risk assessment model (e.g. exposure per event, dose-response constants, ratio of desease/infection ratios, susceptibility fraction) are further detailed in Appendix 2 of the Australian guidelines (NRMMC–EPHC–AHMC, 2006).

The log_{10} reductions established have been calculated considering the worst-case scenario of the irrigation of lettuce when edible parts are in contact with reclaimed water (i.e. sprinkler irrigation) and the only barrier to reduce risk to a tolerable level is the wastewater treatment (secondary treatment, filtration and disinfection). The log_{10} defined reductions are the following:

— *Campylobacter*: 5 log_{10} reduction

— Rotavirus: 6 log_{10} reduction

— *Cryptosporidium*: 5 log_{10} reduction

These results are consistent with the higher disease risk for viruses relative to other enteric pathogens generally obtained when a Quantitative Microbial Risk Assessment (QMRA) is performed for different classes of pathogens (De Keuckelarre *et al.*, 2015).

According to the multiple-barrier approach included in the risk management framework, these $\log_{10}$ reductions can be obtained using several water treatment options alone or in combination with other non-treatment options (e.g. type of crop to be irrigated, irrigation method, post-harvest processing).

These $\log_{10}$ reductions are then applied as $\log_{10}$ reductions of the microbiological indicators selected for each reference pathogen (*E. coli*, F-specific bacteriophages and *Clostridium perfringens* spores) for monitoring purposes. The justification for the selection of these indicators is in Section 4.4.5.

4.4.5 Microbiological parameters for monitoring

The justification for the microbiological parameters selected for monitoring purposes is presented below, for each group of microorganisms (bacteria, viruses and protozoa):

Bacteria: *Escherichia coli* (*E. coli*) and *Legionella* spp.

E. coli is the most suitable indicator of faecal contamination, and it is a traditional bacterial indicator for monitoring purposes in water treatment. Although some guidelines and regulations utilize thermotolerant (faecal) or total coliforms as bacterial indicators for agricultural irrigation (WHO, 2006; USEPA, 2012; CDPH, 2014), *E. coli* is considered more specific of fecal contamination and reflects better the behaviour of the pathogenic enteric bacteria (Ashbolt *et al.*, 2001; NRMMC–EPHC–AHMC, 2006). *E. coli* is the first organism of choice in monitoring programmes including surveillance of drinking-water quality (WHO, 2011), as well as the most commonly used bacterial indicator in national water reuse legislations of MS (JRC, 2014). In addition, *E. coli* is considered an appropriate indicator for the presence/absence of *Campylobacter* in drinking water systems (WHO, 2016). The ISO guidelines establish that *E. coli* and thermotolerant coliforms can be both used for water quality monitoring as the difference in values is not considered significant (ISO 16075, 2015).

Legionella spp. is selected as bacterial parameter following the ISO recommendations (ISO 16075, 2015). *Legionella pneumophila* is a non-conventional opportunistic waterborne pathogen, as it is not transmitted orally. Transmission is through mechanical means, which generate aerosols including sprinklers. *Legionella pneumophila* is on the USEPA Candidate Contaminant List for drinking water purposes as an important pathogen. It is commonly encountered in freshwater environments and in wastewater and there is a potential of growth in distribution systems of reclaimed water in warm climates where suitable temperatures and conditions for their multiplication may be provided (Jjemba *et al.*, 2015). No legionellosis outbreak has been linked to reclaimed water yet, but it is recommended as a reference pathogen for pathogens able to grow in water distribution systems in the revision of Annex I of the Directive 98/83/EC on the quality of water intended for human consumption performed by the WHO (WHO, 2016), although no recommendations for monitoring are made. The ISO guidelines recommend monitoring of *Legionella* spp. only for green houses irrigation with risk of aerosolization (ISO 16075, 2015). *Legionella* spp. is only recommended for monitoring of agricultural irrigation practices in the Spanish regulations, and only when there is risk of aerosolization.

Viruses: Total coliphages/F-specific coliphages/somatic coliphages

Generally, viruses are more resistant to environmental conditions and treatment technologies, including filtration and disinfection, than bacteria (WHO, 2011). Therefore, due to the limitations of bacterial indicators, there has been significant research into determining a viral indicator that may be adopted for water quality monitoring. Two groups of bacteriophages that infect *E. coli*, somatic coliphages and F-specific coliphages, are the major groups that have been used as viral indicators of pathogenic viruses for many years, as they share many properties with human viruses, notably composition, morphology, structure and mode of replication (AWPRC, 1991; Armon et Kott, 1996; Grabow, 2001, Jofre, 2007). Furthermore, regulatory authorities in different parts of the world are beginning to consider coliphages as viral indicators concerning reclaimed water (QEPA, 2005; NCDENC, 2011), biosolids used in agriculture (DEC, 2011) and groundwater (USEPA, 2006).

However, issues such as their potential replication in natural water environments, the cumbersome detection and enumeration methods, a lack of definition concerning which of the two groups should be included in future regulations, and the lack of a clear correlation between coliphages and human viruses and health risks in different water settings remain controversial. Jofre *et al.* (2016) is a recent review article that attempts to shed some light on these contentious issues.

The conclusions of this review article are that: supposing that they can replicate in some natural water settings, the contribution of coliphages replicated outside the gut will not affect the numbers contributed by fecal pollution and detected by strains recommended for standardized methods; there are easy, fast, and cost-effective methods that can be used in routine laboratories after a little training (Méndez *et al.*, 2002); the low correlation of coliphages with human viruses and health risks is no worse than the correlation between different human viruses; perhaps the best option is to determine both groups in a single step. A general conclusion is that coliphages are likely to be better indicators of viruses than the current bacterial indicators (i.e. *E. coli* and enterococci).

In general, somatic coliphages outnumber F-specific coliphages. However, regarding reclaimed water, F-specific coliphages have been observed to be more resistant than somatic coliphages to UV radiation, thus F-specific coliphages surpassing numbers of somatic coliphages. This trend is also observed in clayey sediments, and groundwater from certain aquifers (Jofre *et al.*, 2016).

Coliphages (i.e. somatic coliphages) are recommended for monitoring of high-exposure water reuse schemes in the Australian guidelines, and the WHO guidelines stay that, under certain circumstances, bacteriophages may be included for monitoring to overcome *E. coli* limitations as indicator (NRMMC–EPHC–AHMC, 2006; WHO, 2006).

The USEPA guidelines recognize that alternative indicators to *E. coli* may be adopted in the future for water quality monitoring (e.g. bacteriophages), but they do not include any specific viral indicator in their recommendations (USEPA, 2012). However, regarding indirect potable reuse for surface spreading or direct injection, the USEPA guidelines state that $\log_{10}$ removal credits for viruses can be based on challenge tests (spiking) or the sum of $\log_{10}$ removal credits allowed for individual treatment processes, although monitoring for viruses is not required.

California regulations include F-specific bacteriophages as a performance target (99.999% removal/inactivation from raw wastewater) for food crops irrigation (CDPH, 2014). In addition, US state regulations of North Carolina adopt coliphages as water quality target for irrigation of food crops not processed (USEPA, 2012).

MS regulations for agricultural irrigation do not include coliphages, or any viral indicator, for monitoring, with the exception of the French regulation that includes F-RNA coliphages as performance target for validation monitoring in agricultural irrigation (JRC, 2014).

Due to the different characteristics and behaviour of F-specific coliphages and somatic coliphages, it is recommended the use of total coliphages as viral indicators. However, if this is not feasible, at least one of them must be analyzed.

Protozoa: *Clostridium perfringens* spores/spore-forming sulfate-reducing bacteria

Giardia cysts and *Cryptosporidium* oocysts have been found in reclaimed water (Huffman *et al.*, 2006; USEPA, 2012). This triggered considerable concern regarding the occurrence and significance of *Giardia* and *Cryptosporidium* in water reuse schemes.

E. coli is more readily removed by disinfection methods than protozoa, which are mainly removed by filtration systems. Protozoa also survive longer than bacteria in groundwater. *Clostridium perfringens* spores and spore-forming sulfate-reducing bacteria have been suggested as indicators of protozoan removal and effectiveness of filtration processes. *Clostridium perfringens* spores have an exceptional resistance to disinfection processes and other unfavourable environmental conditions, its spores are smaller than protozoan (oo) cysts, and hence more difficult to remove by physical processes (NRMMC–EPHC–AHMC, 2006; WHO, 2006; WHO, 2011).

Protozoan indicators (i.e. *Clostridium perfringens* spores) are recommended for monitoring of high-exposure water reuse schemes in the Australian guidelines, and the WHO guidelines state that, under certain circumstances, additional indicators *to E. coli* may be included for monitoring (NRMMC–EPHC–AHMC, 2006; WHO, 2006). The DWD and also the draft from the WHO on the revision of Annex I of the DWD include *Clostridium perfringens* spores monitoring for treatment control for disinfection-resistant pathogens such as *Cryptosporidium* (WHO, 2016).

The USEPA guidelines do not include any specific protozoan indicator in their recommendations (USEPA, 2012). As regards of aquifer recharge for potable uses (indirect potable reuse) using surface spreading or direct injection, the USEPA guidelines state that $\log_{10}$ removal credits for *Giardia* and *Cryptosporidium* can be based on challenge tests (spiking) or the sum of $\log_{10}$ removal credits allowed for individual treatment processes, although monitoring for these pathogens is not required (USEPA, 2012).

State regulations of North Carolina have specific water quality limits for *Clostridium* for non-processed food crops, and Florida requires monitoring of *Giardia* and *Cryptosporidium* for food crops irrigation (USEPA, 2012).

MS regulations for agricultural irrigation do not include protozoan indicator for monitoring, with the exception of the French regulation that requests monitoring of spores of sulphite-reducing bacteria as performance target for validation in agricultural irrigation, but this indicator was selected because it was more abundant in wastewater than spores of *Clostridium* (JRC, 2014).

It is recommended to use *Clostridium perfringens* spores as indicator, although spore-forming sulfate-reducing bacteria may be an alternative if the concentration of *Clostridium perfringens* spores does not allow to validate the requested log_{10} removal.

Helminth eggs, intestinal nematodes specifically, are selected to be monitored when reclaimed water is used to irrigate crops to feed livestock in order to control animal health risks. These pathogens are included in Table 2, and the associated justification is shown in Section 4.4.6.

4.4.6 Water quality criteria

The *E. coli* concentrations to be complied with by the reclaimed water effluent for monitoring (Table 2) are established considering the concentration of *E. coli* present in raw wastewater and the log_{10} reduction to be achieved by the microbiological indicator, taking into account the log_{10} reductions to be achieved by the treatment train and by the type of crop to be irrigated, and the reduction achieved by applying different irrigation systems and withholding periods(Table 2). The log_{10} reductions effectiveness of this barriers is established by several guidelines (NRMMC–EPHC–AHMC, 2006; WHO, 2006; USEPA, 2012; ISO 16075, 2015).

Class A has been defined to be able to be applied on the highest health risks which consist on irrigation of crops eaten raw when reclaimed water comes into direct contact with edible parts of the crop, and irrigation of root crops (WHO, 2006). This worst-case scenario only considers the treatment technologies in place as a preventive measure (barrier). Thus, the natural pathogen die-off on crop surfaces that may be from 0.5 to 2 log_{10} unit reduction per day (NRMMC–EPHC–AHMC, 2006; WHO, 2006) is not considered, as this reduction depends on several variables like type of pathogen, climate conditions (i.e. temperature, sunlight intensity, humidity), time interval, and type of crop.

The reduction of 1 log_{10} unit that may be achieved when crops are washed with clean water has not been taken into account to define the water quality targets in this document as this is a process that cannot be controlled by the responsible managers.

Class B, C and D consider the characteristics of the type of crop to be irrigated as a barrier, and also the possibility of using irrigation methods that provide exposure reductions, thus allowing the use of less stringent water quality targets.

The irrigation of pastures and fodder crops with reclaimed water may potentially pose a risk to the health of both livestock and humans through the consumption of animal products. The "species barrier" means that many human pathogens, including human enteric viruses, are not of significant concern for livestock health and, in addition, reduction of bacteria, viruses and protozoa includes also reduction of pathogens for livestock. However, pathogens like helminth parasites eggs such as those of *Taenia saginata* and *Taenia solium* may be present in raw wastewater, especially if slaughterhouses wastewater is present in the urban wastewater treatment plant, although this type of wastewater usually undergoes a treatment before arriving to a WWTP.

A limitation in approaching the livestock health risks associated with reclaimed water is that virtually no dose-response models are available for infection in animals, therefore, water quality targets cannot be derived using a QMRA. Therefore, a practical approach has been proposed following recommendations from the Australian guidelines (NRMMC–EPHC–AHMC, 2006).

The control of *Taenia saginata* in reclaimed water that is to be used in contact with livestock has previously been prescribed through either 25 days of hydraulic retention time in waste stabilization ponds or equivalent treatment (NHMRC and ARMCANZ, 2000). This has been effective management of the risk posed by *T. saginata*. However, there is no guidance on what constitutes an "equivalent treatment". Using the empirical model described by Ayres *et al*. (1992), relating the percentage removal of helminth eggs with detention time in days, a mean hydraulic retention time of 25 days is equal to approximately 4 $\log_{10}$ reduction of helminth eggs. This is the target that alternative treatment processes to stabilization ponds should meet if *Taenia saginata* requires specific management. The concentration of helminth eggs in raw wastewater is in a range of 0 to 10^4 eggs per litre, therefore a limit values of 1 egg/l is selected to be achieved when reclaimed water is used to irrigate pastures or fodder crops. This limit value is also recommended by the WHO to protect human health, considering epidemiological data as there is not sufficient data available to perform a QMRA. In addition, when health risks for livestock were evaluated in a recent study, using reclaimed water for irrigation that complied with the WHO recommendations for water quality none of the animals showed signs of infection or of disease (Bevilacqua *et al.*, 2014). There was also no evidence to suggest any resulting health risk to humans from the consumption of milk from animals fed with reclaimed-water-irrigated forage crops.

This limit value is similar to the value recommended by the ISO standards and is in agreement with the Spanish regulation that includes the same limit values for *Taenia saginata* and *Taenia solium* when milk- or meat-producing animals are to be fed with pastures irrigated with reclaimed water.

Taenia solium ova can infect pigs, causing cysticercus, which may result in human infection with the pig tapeworm if undercooked meat is consumed. *T. solium* infection can cause a severe neurological disease in humans (neurocysticercosis), therefore it has been recommended in Australian guidelines a prohibition of use of reclaimed water for pig fodder due to the severity of the disease, unless there is sufficient data to indicate the risks for a specific case can be managed (NRMMC–EPHC–AHMC, 2006).

The use of reclaimed water can potentially contaminate milk and pose risk to human health when used for dairy cattle. Therefore, a withholding period should be implemented for lactating dairy cattle when pastures are irrigated with reclaimed water (NRMMC–EPHC–AHMC, 2006).

Dermal exposure to microorganisms is also possible, but there is a lack of evidence of health impacts through this route and it is considered unlikely to cause significant levels of infection or illness in the normal population (NRMMC–EPHC–AHMC, 2006). Accidental ingestion of soil particles by agricultural workers or children is a route of exposure that has been considered to be under the tolerable risk applying the WHO limit values recommended, thus for a more stringent values the risk should be also defined as tolerable (WHO, 2006; Mara *et al.*, 2007).

The limit values for *E. coli* are in line with the values established by the ISO guidelines for water reuse in irrigation, which are based on the WHO and USEPA guidelines (ISO 16075, 2015). MS regulations present differences regarding the *E. coli* limit value, and only the Spanish regulation is similar.

Validation monitoring (Table 5) is required only for the most stringent reclaimed water quality criteria, Class A, as this class allows irrigation of food crops consumed raw with edible parts in contact with reclaimed water (using sprinkler irrigation), and without relying on the pathogen die-off due to time interval between last irrigation and harvesting, which is the highest exposure risk scenario. The California regulations also include a $\log_{10}$ reduction to be complied with by F-specific coliphages for irrigation of food crops eaten raw when reclaimed water comes into contact with edible parts of the crop (CDPH, 2014).

The frequencies for water quality criteria monitoring are based on the monitoring frequencies for similar quality classes recommended by Australian guidelines and are also in line with the monitoring frequencies recommended by the ISO guidelines. However, it has to be noted that the ISO guidelines recommend a range of frequencies, stating that the monitoring programme should be adapted to local conditions. MS regulations that apply similar requirements have similar monitoring frequencies (e.g. Spain).

Health outcome targets are based on a defined tolerable burden of disease or level of risk that is considered acceptable. Disability Adjusted Life Years (DALYs) are a measure of burden of disease that is used mainly for microbiological hazards. For chemical hazards, the health outcome target is based on no-observed-adverse-effect levels derived from international chemical risk assessments. Although the application of DALYs to chemical parameters is likely to expand, however, unlike pathogens, there are insufficient data to develop DALYs for most chemical hazards, thus expressing health-based targets for chemical hazards using the DALYs approach has been limited in practice (WHO, 2011).

Regarding chemical compounds in wastewater, the document considers that wastewater from UWWTP that comply with the Directive 91/271/EEC. Therefore, wastewater from industries not included in the UWWTD are not considered. This limits the potential concentration of toxic chemicals in reclaimed water. The evidence of direct health impacts from chemical compounds associated with water reuse in agriculture is very limited (WHO, 2006) probably due to the nature of chemical toxicity. The concentrations of most chemicals in reclaimed water or reclaimed water irrigated products will almost never be high enough to result in acute health effects. Chronic health effects that may be associated with exposure to chemicals (e.g. cancer) usually occur only after many years of exposure and may also result from a variety of other exposures not related to the agricultural use of reclaimed water (WHO, 2006). The use of reclaimed water for irrigation may introduce toxic chemical compounds into soils, and pollutants accumulated in the soils may subsequently be uptaken by crops and pose health risks to humans and animals. A major health concern is due to metals as they can be found in any municipal wastewater effluent. Many of them are biologically beneficial in small quantities but become harmful at high levels of exposure. Plant uptake of heavy metals is highly dependent on soil conditions. Cobalt, copper, and zinc are not likely to be absorbed by irrigated crops in sufficient quantities to prove harmful to consumers and are toxic to plants far before reaching a content that is toxic to humans. However, there WHO guidelines recommend a maximum concentration limit for hexavalent chromium, because it is rapidly reduced to trivalent chromium, which forms a less soluble solid phase in wastewater or soils. Cadmium is the metal that causes the largest risk. Its uptake can increase with time, depending on soil concentration, and is toxic to humans and animals in doses much lower than those that visibly affect plants (WHO, 2006).

Specific considerations on health risks from compounds of emerging concern (CECs) are shown in Section 6.

4.4.7 Physico-chemical parameters for monitoring

The justification for the physico-chemical parameters selected for monitoring purposes is presented below:

- **Biochemical Oxygen Demand (BOD_5)**: this parameter acts as an indication of biological treatment effectiveness and indirect potential for bacterial regrowth in distribution systems. BOD_5 can be considered a surrogate for performance related to pathogen reduction (NRMMC–EPHC–AHMC, 2006).
  BOD_5 appears in the Australian and USEPA guidelines for agricultural irrigation, as well as in other guidelines (NRMMC–EPHC–AHMC, 2006; USEPA, 2012; ISO 16075, 2015). Some MS include BOD_5 in their water reuse legislations for agricultural irrigation (Cyprus, Greece and Italy).
- **Total suspended solids (TSS)**: this parameter indicates effectiveness of sedimentation and it is also related with filtration and disinfection efficacy. The removal of suspended matter is linked to pathogen removal, as many pathogens are particulate-associated, and both bacteria and viruses can be shielded from disinfectants such as chlorine and UV. Furthermore, materials in suspension are listed as pollutants which input has to be limited in Annex VIII of the WFD.
  TSS is included in the USEPA guidelines for monitoring of processed food crops and non-food crops irrigation (USEPA, 2012). The Australian guidelines follow a similar pattern (NRMMC–EPHC–AHMC, 2006). The ISO guidelines include TSS for agricultural irrigation monitoring (ISO 16075, 2015).
  MS regulations include TSS for agricultural irrigation (JRC, 2014).
- **Turbidity**: it is a traditionally used parameter to indicate filtration effectiveness and suitability for disinfection, and can be a surrogate for protozoa removal, and viruses. Turbidity is an important factor both as parameter reflecting the potential of breakthrough of small particles, including pathogens, and because particulate matter in water may shield pathogens from disinfectants, rendering disinfection less effective.
  Turbidity appears in the USEPA guidelines for food crops eaten raw and aquifer recharge, similarly to the Australian guidelines (NRMMC–EPHC–AHMC, 2006; USEPA, 2012). The ISO guidelines include turbidity for irrigation of food crops eaten raw (ISO 16075, 2015). Turbidity is included in the Greek and Spanish water reuse legislations for specific categories of use for agricultural irrigation.
  Monitoring of these parameters is compulsory in order to control environmental risks to soils, plants, surface waters and groundwaters associated with reclaimed water use for agricultural irrigation (e.g. salinity, phytoxicity).
  Agronomic parameters are included in all guidelines for water reuse (WHO, 2006; NRMMC–EPHC–AHMC, 2006; USEPA, 2012; ISO 16075, 2015) and also in water reuse regulations from MS. The specific agronomic parameters and the associated limit values comprised in guidelines and regulations are adapted from the recommendations

made by the Food and Agriculture Organization of the United Nations (FAO) (FAO, 1985). The FAO recommendations are a worldwide reference document that provides a guide to making an initial assessment of agronomic parameters for application of reclaimed water in agriculture. They emphasize the long-term influence of water quality on crop production, soil properties and farm management.

However, almost all water reuse guidelines and regulations have applied some modifications to the FAO recommendations due to their basic assumptions and comments and the number of variables that are site specific when establishing agronomic parameters and values (e.g. soil characteristics, climate conditions, crop variety, cultivation practices like the irrigation method and the hydraulic loading).

MS have to specify minimum quality requirements on a case-by-case basis taking into account site specific conditions, to be complied with by reclaimed water effluent and to be included for monitoring.

Physico-chemical parameters from related EU Directives, some of them included also in the FAO guidelines, are to be complied with by the reclaimed water effluent. As regards MS legislations, the Spanish water reuse legislation states that the use of reclaimed water for agricultural irrigation must respect the EQSD, and the Italian legislation includes some organic contaminants for monitoring in reclaimed water. The Greek regulation for water reuse includes a list of the priority substances from the EQSD, with some modifications, that has to be complied with for reclaimed water quality for all categories of use.

According to the qualitative and quantitative environmental risk assessments described in several guidelines (FAO, 1985; NRMMC–EPHC–AHMC, 2006; WHO, 2006; USEPA, 2012; ISO 16075, 2015), and the experience gathered by MS on agricultural irrigation with reclaimed water, there are key environmental hazards associated to environmental risks that are identified (mostly agronomic adverse impacts), which are salinization, sodicity, toxicity, and nutrient imbalance.

Salinization of soils irrigated with reclaimed water is one of the most important risks. The presence of soluble salts in reclaimed water may lead to accumulation of salts in soils (especially in dry climates), the release of cadmium from soils due to increased chlorine content, reduced rates of plant growth and productivity, water stress due to plants' susceptibility to osmotic effects, changes in native vegetation, groundwater salinization affecting dependent ecosystems, and increased salinity in surface water aquatic systems.

A high proportion of sodium (Na^+) ions relative to calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions in soil or water (sodicity) could degrade soil structure by breaking down clay aggregates, which makes the soil more erodible, causing surface sealing and preventing the movement of water (permeability) and air (anoxia) through the soil, thus reducing plant growth.

The effect of specific toxicity of certain ions to plants (e.g. chloride, boron, sodium, and some trace elements) may lead to reduced crop yields. Some ions may prejudice the microbial activity of the soil, and aquatic biota. In addition, heavy metals and other toxic compounds present in reclaimed water can accumulate in soils or/and in crops, and may reach groundwater or surface water bodies causing their deterioration.

Unbalanced supply of nutrients may result in crop deficiencies and toxicities. Macronutrients like nitrogen, phosphorus and potassium in reclaimed water may be higher than the needs of the crop, or not supplied at an optimal rate for the crop. Excess of nutrients may lead to groundwater deterioration, and surface waters eutrophication.

The limit values for BOD_5, TSS and turbidity established for Class A are based on the ISO guidelines as the most stringent class. This is in line with the water reuse guidelines and MS regulations that apply BOD_5 and TSS values usually in the range of the requirements of the UWWTD, with more stringent requirements only for some uses, like irrigation of food crops eaten raw (NRMMC-EPHC-AHMC, 2006; USEPA, 2012; JRC, 2014). Frequencies defined for all classes are based on Australian and ISO guidelines recommendations.

5 Management of health and environmental risks for water reuse in aquifer recharge

This section includes the definition of the requirements to manage health and environmental risks when reclaimed water is used IN aquifer recharge, following a risk management approach, and the associated justification.

Regarding the source of wastewater to be reclaimed, as a minimum requirement, it has to be stressed that, as for agricultural irrigation, the Directive 91/271/EEC (UWWTD) that concerns the collection, treatment and discharge of urban wastewater, establishes quality requirements that have to be satisfied by discharges from urban wastewater treatment plants (UWWTP) including also specific requirements for discharges in sensitive areas (Annex I of UWWTD). Water from wastewater treatment plants destined for reuse is considered a discharge under the UWWTD at the point where it leaves the water treatment plant (after treatment) (EC, 2016). Therefore, as the only source of wastewater considered in this document is the wastewater covered by the UWWTD, all treated wastewater potentially considered for reclamation and reuse (i.e. wastewater coming from an UWWTP) has to comply, **at least**, with the quality requirements specified in the UWWTD Annex I, table 1 and, when applicable, with the requirements from Annex I, table 2 for sensitive areas.

In order to assure that wastewater that enter a UWWTP is included in the Annex III of the Directive 91/271/EEC, thus, it is necessary to establish source control programs and oversight of industrial and commercial discharges to the sewer systems connected to a wastewater treatment plant.

5.1 Aquifer recharge uses

Aquifer recharge refers, in the present document, to managed aquifer recharge, leaving incidental aquifer recharge out of the scope of this document.

There is no definition at EU level of managed aquifer recharge (MAR), thus, a common definition of MAR at EU level is needed. In this regard, the definition considered is the one included in the Australian Guidelines for Water Recycling: Managed Aquifer Recharge (NRMMC–EPHC–NHMRC 2009). Managed aquifer recharge (MAR) is defined as the intentional recharge of water (reclaimed water in this document) to aquifers for subsequent recovery or environmental benefit.

Although the WFD provides a definition for “aquifer” that applies to this document, the difficulties in physically delimiting an aquifer, especially in the case of fractured karstic subsoil should be acknowledged.

The purposes for managed aquifer recharge considered in this document are the following:

- Establish saltwater intrusion barriers in coastal aquifers.
- Provide storage for the recharged water for subsequent retrieval and reuse.
- Maintain groundwater dependent terrestrial and aquatic ecosystems.
- Dilute saline or polluted aquifers.
- Control or prevent ground subsidence.

All types of aquifers are contemplated in this document for potentially being recharged with reclaimed water. This document considers that all freshwater aquifers are potentially exploitable as potable water source. Furthermore, different aquifers may be connected, especially in karstic areas. Therefore, the present document doesn't differentiate quality requirements according to the present or future use of the aquifer but only according to its present quality and environmental objective under the WFD.

It is to be noted that the present document includes indirect potable reuse as a potential use of managed aquifer recharge. However, this document does not intend to promote water reuse for direct drinking water purposes.

All existing recharge methods for managed aquifer recharge are allowed when using reclaimed water. Recharge methods can be grouped in two main categories: surface spreading and direct injection (NRMMC-EPHC–NHMRC, 2009; USEPA, 2012; CDPH, 2014). MS water reuse regulations that include aquifer recharge with reclaimed water apply this distinction between surface spreading and direct injection (JRC, 2014).

Surface spreading is a method of recharge whereby the water moves from the land surface to the aquifer by infiltration and percolation through the vadose zone (Regnery *et al.*, 2013). Direct injection recharge is achieved when water is pumped directly into the groundwater zone (i.e. saturated zone), usually into a well-confined aquifer (USEPA, 2012).

Article 11.3(j) of the WFD includes a ‘prohibition of direct discharges of pollutants into groundwater’ as a basic measure. Water reuse schemes, therefore, should be designed so as not to allow direct discharges of pollutants into groundwater. This prohibition should be seen as complementary to the above mentioned controls imposed by Article 11.3(f) and the requirements of Article 6 of the Groundwater Directive. It follows that reuse of treated wastewater for recharge of aquifers can contribute to the achievement of WFD objectives, as long as the water is of sufficient quality. It follows that neither the WFD nor the GWD excludes, in principle, a direct injection of treated wastewater for managed aquifer recharge which is permitted in accordance with Article 11.3(f) of the WFD.

5.2 Risk management framework for managed aquifer recharge

MS have to apply the elements of a risk management framework described in Section 4.2 to manage health and environmental risks derived from the use of reclaimed water for managed aquifer recharge.

The required reclaimed water quality criteria for managed aquifer recharge has to be defined on a case-by-case basis because it is considered site specific. As stated above, quality requirements, for managed aquifer recharge are only differentiated, in this document, according to the existing groundwater quality and the environmental objectives under the WFD. Therefore, a site-by-site approach is necessary. In addition, due to the range of aquifer characteristics that come into play, it is difficult to use performance at one aquifer recharge site to predict performance at another.

Groundwater protection is the overarching aspect when aquifer recharge is performed. In this regard, the Directive 2006/118/EC amended by Directive 2014/80/EU (Groundwater Directive (GWD)) complements the WFD and the objective of the GWD is to protect groundwater against pollution and deterioration through the establishment of specific measures to prevent and control groundwater pollution. MS must assure that the quality of reclaimed water for managed aquifer recharge does not compromise the objectives of the GWD and related Directives. MS have to establish, if necessary, minimum quality requirements for the parameters included in the related EU directives on a case-by-case basis to be complied with by the reclaimed water effluent and to be included for reclaimed water criteria in the verification monitoring.

An aquifer characterization has to be performed following the requirements established in the GWD in accordance with Article 5 of the WFD. Advanced modelling tools are advised to be used. Guidance documents and technical reports have been produced by the Common Implementation Strategy (CIS) of the WFD to assist MS to implement the WFD, and some of them are tools to support aquifer characterisation as they provide guidance on, for instance, establishing groundwater monitoring programmes for status and trend assessment (EC, 2007a; EC, 2007b; EC, 2009). Guidance documents are intended to provide an overall methodological approach, but these will need to be tailored to specific conditions of each case. Furthermore, the Environmental Impact Assessment Directive (2014/52/EU) (amending Directive 2011/92/EU) requires that managed aquifer recharge schemes where the annual volume of water recharged is equivalent to or exceeds 10 million m^3 have to undergo an environmental impact assessment.

Considering the risks from chemical substances, the GWD (Article 6) demands establishment of measures to prevent or limit inputs of pollutants into groundwater. These measures have to prevent inputs of any hazardous substances, in particular taking into account hazardous substances belonging to the families or groups of pollutants referred to in points 1 to 9 of Annex VIII of the WFD, where these are considered to be hazardous (including priority hazardous substances of the EQSD). The measures also have to limit inputs of pollutants from Annex VIII of the WFD which are not considered hazardous and any other non-hazardous substances not listed in Annex VIII considered to present an existing or potential risk of pollution, so as to ensure that such inputs do not cause deterioration or significant and sustained upward trend in the concentration of pollutants in groundwater. According to the GWD (amended by Directive 2014/80/EU) MS have to establish threshold values for groundwater pollutants and indicators of pollution on a national, river basin district or other appropriate level having regard dependent ecosystems and regional or even local conditions.

Besides the parameters of the GWD, additional hazards may also affect groundwater, and dependent ecosystems according to the potential hazards of the wastewater effluent to be treated for reuse and site specific conditions. In addition, when surface spreading is used as a recharge method, MS have to avoid adverse effects to the soil and related dependent ecosystems where reclaimed water is spread. Therefore, following an environmental risk assessment, MS have to establish, if necessary, minimum quality requirements for additional parameters not included in the GWD to be complied with by the reclaimed water effluent and to be included in the reclaimed water quality criteria in order to avoid adverse effects on groundwater and soils and related dependent ecosystems.

MS have to implement monitoring programs of the environmental matrices at risk to control the effect of managed aquifer recharge with reclaimed water irrigation as part of the verification monitoring. A monitoring program has to be established, on a case-by-case basis, according to the identified risks.

Considering risks from health hazards (i.e. pathogens) these have to be prevented or limited from entering the aquifer considering the existing groundwater quality following the principle of no deterioration. No additional treatment has to be applied to the recovered water to comply with the water quality required for the intended use compare to the groundwater quality before recharge. Since the indirect potable use is always to be considered, a Quantitative Microbial Risk Assessment (QMRA) is always needed.

When establishing reclaimed water quality parameters for managed aquifer recharge, it has to be considered the recharge method. Managed aquifer recharge by surface spreading will provide added benefits to reclaimed water quality that direct injection is unable to, due to the natural attenuation capacity of the **vadose zone**. Surface spreading makes reclaimed water to pass through the vadose zone (i.e. unsaturated zone), hence allowing mechanisms that may result in attenuation or degradation of substances and microorganisms content, as filtration, adsorption, precipitation, volatilisation, biodegradation, and microbial assimilation to take place (Van Houtte and Verbauwhede, 2008, NRMMC-EPHC–NHMRC, 2009). The GWD states that processes in the vadose zone that result in attenuation or degradation of substances may be taken into account when considering measures to prevent or limit input into groundwater. It also indicates that the natural attenuation capacity of the unsaturated zone may be taken into account when defining measures for both the *preventing* and *limiting* objective. For *limiting* even processes taking place in the saturated zone may be considered.
MS must assess the removal capacity of the vadose zone, on a case-by-case basis, in order to establish less stringent reclaimed water quality requirements for managed aquifer recharge by surface spreading, if applicable. However, as stated above, the adverse effects on soils and dependent ecosystems over the time have to be assess.

Removals in aquifers are primarily related to the residence time of the recharge water, the activity of the indigenous groundwater microorganisms, the redox state of the aquifer, and the temperature. Residence time in the aquifer induce an attenuation of human pathogens and selected organic chemicals. MS have to evaluate the variables that may contribute to the removal of hazards. However, there are considerable challenges in validating and continually demonstrating the attenuation of pathogens in aquifers. The scientific literature demonstrating the removal of pathogens in managed aquifer recharge is limited, only a few pathogens have been studied, and in many cases these are not the worst-case target pathogen (NRMMC-EPHC–NHMRC, 2009; USEPA, 2012).

Reclaimed water must comply with the quality criteria established by MS at the outlet of the treatment plant.

Analytical methods used for monitoring shall comply with the requirements included in the related Directives (i.e. WFD (2000/60/EC), DWD (98/83/EC), GWD (2006/118/EC) to conform to the quality control principles, including, if relevant, ISO/CEN or national standardized methods, to ensure the provision of data of an equivalent scientific quality and comparability.

MS may use the Australian guidelines for managed aquifer recharge (NRMMC-EPHC–NHMRC, 2009) as a guidance to assess and manage environmental risks for managed aquifer recharge, as the risk management framework is applied in that guidelines.

Following the same approach as for agricultural irrigation, MS have to develop an operational monitoring protocol to assess and confirm that the performance of preventive measures of the water reuse system ensures reclaimed water of an appropriate quality to be consistently provided. Examples of operational monitoring requirements for the preventive measure of wastewater treatment processes are shown in Table 1 and are described in the Australian guidelines for managed aquifer recharge (NRMMC-EPHC–NHMRC, 2009).

5.3 Justification for the selected requirements

The case-by case approach selected for managed aquifer recharge quality requirements is recommended by the Australian guidelines for managed aquifer recharge (NRMMC-EPHC–NHMRC, 2009), the USEPA guidelines (USEPA, 2012) and the California regulations (CDPH, 2014). The USEPA guidelines and the California regulations establish specific quality requirements for indirect potable reuse through managed aquifer recharge, similar to drinking water quality requirements, as they differentiate between potable and non-potable aquifers.

The GWD is the EU Directive most directly related to managed aquifer recharge. Considering the hazards potentially present in wastewater, microbiological and chemical hazards, a risk assessment is to be performed to assess additional hazards not contemplated in the GWD that may represent a health or environmental risk. This is also in line with guidelines and regulations that include managed aquifer recharge with reclaimed water as site specific for managing risks (NRMMC-EPHC–NHMRC, 2009; USEPA, 2012; CDPH, 2014).

This situation of a highly site-specific framework of boundary conditions to be considered for aquifers makes it very challenging to establish EU-wide parametric values to be implemented.

6 Compounds of emerging concern

This section addresses the subject of the compounds of emerging concern related to the use of reclaimed water for agricultural irrigation and aquifer recharge.

6.1 Knowledge and gaps

With the advance of analytical techniques a number of chemical compounds, which are not commonly regulated, have been detected in drinking water, wastewater, or the aquatic environment, generally at very low levels. This broad and growing group of chemicals is termed Compounds of Emerging Concern (CECs) (or sometimes in a misleading way emerging pollutants). The concern is due to either a knowledge gap about the relationship of the substances' concentrations and possible (eco)toxicological effects – usually due to chronic exposure, or the lack of understanding how such substances interact as chemical mixture. CECs are not necessarily new compounds and might have been present in the environment for a longer time, while their presence and significance are only recognised now. While the Water Framework Directive addresses the issue through a process of structured prioritization, no precises relationship is established between the occurrences and levels of CECs in (treated) wastewater and the acceptable level in the aquatic environment.

CECs include groups of compounds categorized usually by end use (e.g. pharmaceuticals, non-prescription drugs, personal care products, household chemicals, food additives, flame retardants, plasticizers, disinfection-by-products, and biocides), by environmental and human health effects (e.g. hormonally active agents, endocrine disrupting compounds [EDCs]), or by type of compound (e.g. chemical vs. microbiological, antibiotic resistance gens, phenolic vs. polycyclic aromatic hydrocarbons), as well as transformation products resulting from various biotic and abiotic processes, and mixtures of chemicals (WHO, 2011; USEPA, 2012).

It is commonly accepted that today a frequent monitoring for every potential chemical substance is neither feasible nor plausible. Research is focusing on the development of a science-based framework to guide the identification of CECs that should be monitored or otherwise regulated, including the context of reclaimed water use, especially for potable use (Drewes *et al.*, 2013). A sound selection framework is needed that can provide a short list of meaningful indicator measurements that can address both human health relevance and assurance of proper performance of water treatment processes in addition to routine monitoring for compliance with guidelines and/or regulations.

As presented by Paranychianakis *et al.* (2014) in a review paper, a few studies have shown that the uptake, translocation and the accumulation of a wide range of emerging chemicals in crop tissues is in overall low and does not pose significant risks for public health. Moreover, plants possess metabolic pathways that might transform and degrade organic pollutants further decreasing the potential risks.The health risks resulting from the ingestion of food exposed to 22 chemicals revealed a safety margin greater than 100 for all the substances identified in the irrigation water, except gemfibrozil. The risks related to the direct use of pesticides applied to crops appear to be of greater importance. Paranychianakis *et al.*, 2014 continues hence that the concern regarding CECs focuses on potable reuse applications. Considering the wide diversity of organic chemical structure, some are relatively easy to attenuate, while others are more recalcitrant (Paranychianakis *et al.*, 2014). Aquifer recharge through infiltration can be highly effective in the removal of many contaminants, though some can persist into the underlying groundwater (Laws *et al.*, 2011).

While a broad range of publications have investigated the occurrence of CECs, the role of CECs in agricultural systems is poor, reason for which the Organisation for Economic Cooperation and Development (OECD) investigated the issue through a high-level expert team (OECD, 2012). The report carefully assesses the state-of-the-art and identifies and suggests measures for risk mitigation. It is noteworthy that the report does not identify or mention the use of treated wastewater for agricultural irrigation as a significant entry pathway. However, it also states that it is possible that important pathways would have been overlooked and identifies a list of priority actions to fill knowledge gaps.

Among, these the lack of long-term exposure data to trace organics constrains the accurate quantification of the health risks (Paranychianakis *et al.*, 2014). The available data show great temporal and spatial variations in the concentration of organics as a result of the source concentrations and treatment processes.

It should be noted that the existing data are not sufficient to set ecological limits for most organics. Critical information is required for many disciplines to obtain a better understanding of the ecological impacts of water reuse on aquatic organisms of CECs and their mixtures on biodiversity, biogeochemical cycles of nutrients, ecosystems functions and services, and their resilience to environmental stressors (Paranychianakis *et al.*, 2014).

Most of the scientific literature regarding the assessment of CECs' uptake by plants is focused on experiments on plant uptake and bioavailability in artificially amended soils or contaminated growing media and biosolids (Fatta-Kassinos *et al.*, 2016). The same authors conclude that the agricultural use of biosolids is a significantly greater reservoir for plant uptake of CECs than irrigation with treated wastewater.

Prosser and Sibley (2015) carried out an assessment that indicates that the majority of individual pharmaceuticals and personal care products (PPCPs) in the edible tissue of plants due to biosolids or manure amendment or wastewater irrigation represent a *de minimis* risk to human health. Assuming additivity, the mixture of PPCPs could potentially present a hazard. Further work needs to be done to assess the risk of the mixture of PPCPs that may be present in edible tissue of plants grown under these three amendment practices (Prosser and Sibley, 2015).

6.2 Anti-microbial resistances

Among the CECs the issue of antimicrobial resistance (AMR) is of growing concern. AMR threatens the effective prevention and treatment of an ever-increasing range of infections caused by bacteria, parasites, viruses and fungi. In 2014, WHO has published a first global assessment on the current status of surveillance and information on AMR, in particular antibacterial resistance (ABR), at country level worldwide (WHO, 2014). In a joint report, the European Food Safety Authority and the European Centre for Disease Prevention and Control (EFSA and ECDC, 2015) looked into the antimicrobial resistance data on zoonotic and indicator bacteria in 2013, submitted by 28 EU MS. Resistance in zoonotic *Salmonella* and *Campylobacter* species from humans, animals and food, and resistance in indicator *Escherichia coli* and enterococci, as well as data on meticillin-resistant *Staphylococcus aureus*, in animals and food were addressed. Although mentioning that the bacterial resistance to antimicrobials occurring in food-producing animals can spread to people not only via food-borne routes, but also by routes such as water or environmental contamination (e.g. at slaughter) no further information is provided on the relevance of treated wastewater use as a possible pathway.

However, the spreading of antibiotic resistance genes (ARG) due to water reuse practices such as irrigation of crops and landscapes, and augmentation, conservation or restoration of surface water bodies has being received particular concern in the last years. Since the discovery of antibiotics and their wide spread use in medicine, stockbreeding and aquaculture, the occurrence of ARG in the environment has been increasing. Thanner *et al.* (2016) looked more specifically into the issue of AMR in agriculture and clearly state that a proper risk analyses regarding ARB "*require comparable data across different biomes: soil, plant, animal, humans, water*". A conclusive risk assessment is currently virtually impossible, a situation which according to the same authors has created great differences within the scientific community.

It appears also that more information is required to obtain a clear picture of the risks associated with water reuse applications. The adoption of (meta)genomic approaches which provide information on the whole microbial community and not only to the culturable portion of microorganisms will improve our understanding on the mechanisms responsible for the induction of ARG, their spreading and how they differ among the different taxa.

On the other hand, no difference in the abundance of ARG among fresh and recycled water irrigated soils was detected in a study carried out in Israel (Negreanu *et al.*, 2012) suggesting that the majority of resistant to antibiotics bacteria entering the soils cannot survive. The high abundance of ARGs in the soil reported often is probably indicative of native antibiotic resistance associated with the soil microbiome (Negreanu *et al.*, 2012). This argument finds confirmation in other findings emphasizing the importance of natural environment in antibiotic resistance (Wellington *et al.* 2013, Paranychianakis *et al.*, 2014).

Although a great deal of information, amongst others compiled by the COST NEREUS action, indicate that domestic wastewater is amongst a likely major environmental reservoirs, the issue of antimicrobial resistance (AMR) has to be addressed in a general context of wastewater sanitation rather than specifically for reuse schemes. Evidence seems actually to indicate that a reuse for irrigation leads to a removal of AMR, since most of the resistant bacteria cannot survive in the receiving soils. A respective minimum requirement for AMR is hence neither justified, nor feasible to the lack of inconclusive and comparable data.

6.3 Measurements and testing

Although great progress has been made in developing novel tools and approaches to "grasp" better CECs including AMR through their (eco) toxicological effects, these tools remain at a pre-market level or have not even reached such a maturity. This vicious circle of "not-being-measured", "no limit value" and "not-inclusion in legislation" can only be broken by further targeted research.

The EU Technical Report on aquatic effect-based monitoring tools (EC, 2014b) presents, in the context of the WFD, a range of effect-based tools (e.g. biomarkers, bioassays) that could be used in the context of different monitoring programmes, and that might be able to take account of the presence of several known and unknown compounds with similar effects.

Effect-based tools could be used as a screening and prioritisation tool for subsequent chemical analysis. Nevertheless, there is still significant uncertainty regarding the role of effect-based tools in a regulatory context and developments in bioanalytical science should be examined to identify validated bioassay candidates.

Similar considerations apply for AMR/ARG dimension, where the scientific community is far from having reached a consensus on reference and indicator resistances and a (commercially viable) way to quantify them.

7 Conclusions

Water is a limited resource and hydric stress an increasing challenge at EU and global level. Linked with growing needs of the population and regionally aggravated by climate change, water scarcity is fast becoming a concern across the EU. Existing water resources in Europe are not always managed efficiently. Treated water from urban wastewater treatment plants can provide a source for a reliable water supply Water reuse needs to be considered as a measure within the context of the water policy hierarchy.

Although the use of reclaimed water is an accepted practice in several EU countries, the uptake of water reuse solutions remains limited in comparison with their potential. One of the main barriers identified is the lack of harmonization in the regulatory framework to manage health and environmental risks related to water reuse at the EU level, and thus a lack of confidence in the health and environmental safety of water reuse practices. The development of minimum quality requirements for water reuse for agricultural irrigation and aquifer recharge at EU level have the aim of helping to overcome this barrier.

A risk management framework has been selected for the establishment of the minimum quality requirements. This framework is recommended by the WHO as the most suitable approach to control health and environmental risks of water reuse practices. The key principles of the risk management framework are defined and minimum quality requirements are settled for agricultural irrigation and aquifer recharge. Monitoring recommendations are also included.

For agricultural irrigation, different crop categories are established, and microbiological and physico-chemical parameters are selected. According to the multiple barrier approach, and the health risk assessments developed in international guidelines, specific limit values are defined according to the tolerable risk (burden of disease) of 10^{-6} DALYs pppy. Environmental risks are recommended to be considered on a case-by-case basis taking into consideration site-specific characteristics. The national regulations and guidelines on water reuse already issued by some Member States where also taken into consideration.

For aquifer recharge, the Groundwater Directive is the overarching document to be complied with for groundwater protection. In addition, MS have to apply a risk assessment to control health and additional environmental risks that may arise from the use of reclaimed water.

It is of paramount importance to develop further guidance on the health and environmental risk assessment and the establishment of a risk management framework in general.

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List of abbreviations and definitions

ABR	Antibacterial Resistance
AHMC	Australian Health Ministers' Conference
AMR	Antimicrobial Resistance
ANZECC	Australian and New Zealand Environment and Conservation Council (Note: in 2001, the functions of ARMCANZ and ANZECC were taken up by the Environment Protection and Heritage Council and the Natural Resource Management Ministerial Council)
APHA	American Public Health Association
Aquifer	A subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater (according to Directive 2000/60/EC).
ARG	Antibiotic Resistance Genes
ARMCANZ	Agricultural and Resource Management Council of Australia and New Zealand (Note: in 2001, the functions of ARMCANZ and ANZECC were taken up by the Environment Protection and Heritage Council and the Natural Resource Management Ministerial Council)
bdl	Below Detection Limit
BOD_5	5 day Biochemical Oxygen Demand
CAC	Codex Alimentarius Commission
CCR	California Code of Regulations
CDPH	California Department of Public Health
CECs	Compounds of Emerging Concern
CEN	European Committee for Standardization
cfu	colony forming unit
CIS	Common Implementation Strategy
COD	Chemical Oxygen Demand
COM	Communication from the Commission
Critical limit	A prescribed tolerance that distinguishes acceptable from unacceptable performance.
Ct	The product of residual disinfectant concentration (C) in milligrams per litre and the corresponding disinfectant contact time (t) in minutes.
DALYs	Disability Adjusted Life Years
DG ENV	Directorate General Environment (European Commission)

Domestic wastewater	Wastewater from residential settlements and services which originates predominantly from the human metabolism and from household activities (according to Directive 91/271/EEC).
Dose–response	The quantitative relationship between the dose of an agent and an effect caused by the agent.
DWD	Drinking Water Directive
EC	European Commission
ECDC	European Centre for Disease Prevention and Control
EDC	Endocrine Disrupting Compound
EDCs	Endocrine Disrupting Compounds
EEA	European Environment Agency
EFSA	European Food Safety Authority
EPHC	Environment Protection and Heritage Council
EQSD	Environmental Quality Standards Directive
EU	European Union
Exposure assessment	The estimation (qualitative or quantitative) of the magnitude, frequency, duration, route and extent of exposure to one or more contaminated media.
FAO	Food and Agriculture Organization
Further treatment	Treatment processes, beyond secondary or biological processes, which further improve effluent quality, such as filtration and disinfection processes.
GWD	Groundwater Directive
HACCP	Hazard Analysis and Critical Control Points
Hazard	A biological, chemical, physical or radiological agent that has the potential to cause harm to people, animals, crops or plants, other terrestrial biota, aquatic biota, soils or the general environment.
Hazardous event	An incident or situation that can lead to the presence of a hazard.
Indirect potable reuse	Discharge of reclaimed water directly into a suitable environmental buffer (groundwater or surface water) with the intent of augmenting drinking water supplies, thus preceding drinking water treatment.
Industrial wastewater	Any wastewater which is discharged from premises used for carrying on any trade or industry, other than domestic wastewater and run-off rain water (according to Directive 91/271/EEC).
ISO	International Organization for Standardization

JRC	Joint Research Centre (European Commission)
Log_{10} removal	Used in reference to the physical-chemical treatment of water to remove, kill, or inactivate microorganisms such as bacteria, protozoa and viruses (1 log_{10} removal = 90% reduction in density of the target organism, 2 log_{10} removal = 99% reduction, 3 log_{10} removal = 99.9% reduction, etc).
Managed aquifer recharge	The intentional recharge of water (reclaimed water in this document) to aquifers for subsequent recovery or environmental benefit (according to NRMMC–EPHC–NHMRC, 2009).
MAR	Managed Aquifer Recharge
More stringent treatment	Includes treatment beyond secondary treatment processes (N- and/or P removal) for discharges from urban waste water treatment plants to sensitive areas which are subject to eutrophication. One or both parameters may be applied depending on the local situation (according to Directive 91/271/EEC).
MS	Member States
NHMRC	National Health and Medical Research Council
no	Number
NRC	National Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	Nefelometric Turbidity Unit
NWRI	National Water Research Institute of the United States
OECD	Organisation for Economic Cooperation and Development
PDT	Pressure Decay Test
pfu	plaque forming unit
Population equivalent	The organic biodegradable load having a five-day biochemical oxygen demand (BOD_5) of 60 g of oxygen per day.
PPCs	Pharmaceuticals and personal care products
pppy	per person per year
Preventive measure	Any action and activity that can be used to prevent or eliminate a health and environmental hazard, or reduce it to an acceptable level.
Primary treatment	Treatment of urban wastewater by a physical and/or chemical process involving settlement of suspended solids or other processes in which the BOD_5 of the incoming wastewater is reduced by at least 20% before discharge and the total suspended solids of the incoming wastewater are reduced by at least 50% (according to Directive 91/271/EEC).

QMRA	Quantitative Microbial Risk Assessment
Raw wastewater	Wastewater that has not undergone any treatment, or the wastewater entering the first treatment process of a wastewater treatment plant.
Reclaimed water	Urban wastewater that has been treated to meet specific water quality criteria with the intent of being used for a range of purposes. Synonymous with recycled or reused water.
Risk	The likelihood of identified hazards causing harm in a specified timeframe, including the severity of the consequences.
SAR	Sodium Adsorption Ratio
SCHEER	Scientific Committee on Health, Environmental and Emerging Risks
Secondary treatment	Treatment of urban wastewater by a process generally involving biological with a secondary settlement or other process in which the requirements established in Table 1 of Annex I of Directive 91/271/EEC are respected.
SSP	Sanitation Safety Planning
Target criteria	Performance goals to provide early warning that a critical limit is being approached.
TOC	Total Organic Carbon
TSS	Total Suspended Solids
Urban wastewater	Domestic wastewater or the mixture of domestic wastewater with industrial wastewater and/or run-off rain water (according to Directive 91/271/EEC).
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
UWWTD	Urban Wastewater Treatment Directive
Water reuse	Use of treated wastewater for beneficial use. Synonymous with water reclamation and water recycling.
WFD	Water Framework Directive
WHO	World Health Organization
WSP	Water Safety Plans
WWTP	Wastewater Treatment Plant

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Informative Annex

The Continuous[1] Water Quality Monitoring (CWQM) approach

Research and innovation on continuous physico-chemical and microbiological monitoring is rapidly advancing, often funded by EU innovation programmes. Nowadays, the water quality parameters recommended for the verification of reclaimed water can be continuously monitored for most chemical and physical parameters. Turbidity and TSS are already available with commercial probes. The continuous monitoring of bacterial indicators, as *E. coli*, has been recently demonstrated[2], and BOD_5 related monitoring devices are almost ready to market (applying direct or indirect measurement methods).

Regarding the CWQM technologies for microbiological parameters, there are available devices with two different approaches: detection and measuring. Detection devices are suitable for applications where just the simple presence of microorganisms represents an early warning (drinking water applications, process water for food industry). However, in reclaimed water use for irrigation and aquifer recharge, concentrations of microorganisms below a threshold are allowed for some practices. Thus, in several applications, simple detection will not be suitable if not combined with other measures, and measuring the concentration will be required.

The traditional approach, based on manual sampling and standardized analytical methods, defined for verification monitoring provides the results after 1 to 4 days, depending on the target parameter. Such delay makes the obtained results not suitable for early warning purposes, neither for process control and optimization (operational monitoring). When reclaimed water is reused to irrigate crops, it will be distributed and utilized far before analysis results will be available. In case of a pollution event, the microbial contamination will have spread along the irrigation infrastructure, and the crops could be not anymore suitable for the market. The availability of proven CWQM devices, providing the results in shorter timeframes, will definitely help to close the gap between operational needs and verification monitoring.

In this sense, the CEN/SABE ENV Team (Environmental Monitoring Strategy Team) is preparing a Strategic Position Paper on “Standardization needs in continuous water quality monitoring”, to be delivered by the end of 2017[3]. The paper analyses the added-value of CWQM devices, the barriers to their adoption, and the measures to encourage a more rapid uptake of the innovations, as the ISO/CEN standardization. Additionally in 2014 SABE adopted a position paper[4] on water reuse which identified recommendations on water reuse and implications for future standardization. However, standardization might become a long process for potentially excellent CWQM technologies that may find difficulty penetrating the market.

In order to provide independent verification of the performance of environmental technologies that cannot be fully assessed through certification or labels, and to improve the penetration of these technologies into the EU and global markets, the EC launched the EU Environmental Technologies Verification[5] pilot programme (ETV) in December 2011. The ETV is a suitable, faster and more affordable process to assess performance of CWQM devices compared to the traditional methods and make results available for the whole EU. “This opens up the water directives for scientifically validated technologies, either lab-based or online, and eliminates the need to address requirements for monitoring technologies in the directive itself, with the risk of being outdated shortly after each revision“[6]. Summing up, the CWQM sector is fast moving at the pace of new technologies, therefore whatever standardization or regulation need to be open enough to do not block ongoing innovation.

[1] The ‘continuous’ concept refers to real time, but also to semi-continuous or near real time, providing measurements at a given frequency.

[2] http://r3water.eu/wp-content/uploads/2014/04/R3Water-Final-Brochure-2017_online.pdf

[3] https://www.cencenelec.eu/News/Brief_News/Pages/TN-2017-006.aspx

[4] https://www.cencenelec.eu/news/policy_opinions/PolicyOpinions/ReplyWasteWater2014Nov.pdf

[5] https://ec.europa.eu/environment/ecoap/etv_en

[6] https://www.eipwater.eu/sites/default/files/AG100%20RTWQM%20water%20legislation_whitepaper_v2_150714_def.pdf (Sections 3.3, 3.4 and 4)

With courtesy of EIP Water – Action Group (AG100) Real Time Water Quality Monitoring (RTWQM).

Annex 7a - Non-technical summary of JRC technical report on the development of minimum quality requirements for water reuse in agricultural irrigation and aquifer proposed

Overall non-technical summary of the JRC report

The objective of the JRC report is to define at European level common minimum requirements on water quality, which ensure safety for health and the environment in case that water is reused for agricultural irrigation or for aquifer recharge. This scientific report from the JRC defines these technical parameters on water quality which are as a minimum to be respected in case that treated wastewater is reused for the purposes of agricultural irrigation or for aquifer recharge. Therefore these criteria on water quality make sure that all agricultural products in Europe which were irrigated with treated wastewater are safe for health and for the environment. It does not establish any target for levels or quantity of water to be reused and it allows Member States to establish more stringent criteria, if they see a need for it.

The only source of treated wastewater considered in this proposal was the urban wastewater covered by Directive 91/271/EEC (Urban Wastewater Treatment Directive UWWTD) where urban wastewater is defined as domestic wastewater or the mixture of domestic wastewater with industrial wastewater and/or run-off rain water. The document does not deal with reclaimed water from other industrial sources: industrial wastewaters may have very particular characteristics in relation to quality and they may require specific quality criteria.

For the purposes of developing the proposal, the JRC carried out as a first step a review of the available scientific, technical and legal knowledge on water reuse in agricultural irrigation and aquifer recharge. The documents that have been the basis to establish the proposal for minimum quality requirements included:

- the regulatory framework at EU level on health and environmental protection;
- the MS water reuse legislations and guidelines in place, along with their experience in water reuse systems;
- world-wide reference guidelines and regulations on water reuse;
- additional scientific references considered relevant for the topic.

During the development of the proposal a tiered approach for consultation was applied by the JRC. In the first tier, the JRC asked a group of selected experts from academia, the water sector and WHO to provide input and comment on the drafting work. In a second tier, Member States were formally informed through the Ad-hoc Group on Water Reuse, where JRC presented a three occasions the respective versions. Comments received in writing from the MS were documented and replies from JRC were disseminated. In addition, the JRC presented at several public events as well as scientific meetings the progress of work. These presentations included amongst others the Water Group of the European Parliament, the EIP Water Action Group on Water Reuse, 11th IWA International Conference on Water Reclamation and Reuse as well as the COST NEREUS Action on New and Emerging Challenges and Opportunities in Wastewater Reuse.

Considering the sensitivity of the health and environmental issue and public confidence in water reuse practice, in the third tier, the scientific opinions of the independent Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) and the European Food Safety Authority (EFSA) have been requested and taken into consideration in the finalisation of the document or if not, a justification has been provided.

The experts, whose contributions are gratefully acknowledged, have been consulted to provide comments and input through critical discussion on the document along the process. However, the content of this document has not been endorsed by these experts and reflects only the scientific opinion of the JRC. It is important to note that no risk assessment specifically for the establishment of the minimum quality requirements has been performed and the JRC bases its proposal on the validity of the risk assessment conducted by the reference documents taken into consideration.

The approach to develop minimum quality requirements for the safe use of reclaimed water for agricultural irrigation and aquifer recharge is a risk management framework, as recommended by the World Health Organization WHO (2006) and included in the Directive 2015/1787 that amends Directive 98/83/EC on the quality of water intended for human consumption.

A risk management framework is a systematic management tool that consistently ensures the safety and acceptability of water reuse practices. A central feature is that it is sufficiently flexible to be applied to all types of water reuse systems, irrespective of size and complexity.

The risk management framework proposed by the JRC in conjunction with specific numerical values for some water quality parameters, incorporates several interrelated elements, each of which supports the effectiveness of the others. Because most problems associated with reclaimed water schemes are attributable to a combination of factors, these factors need to be addressed together to ensure a safe and sustainable supply of reclaimed water.

In EU Member States, the most comprehensive water reuse regulations and recommendations issued by MS (i.e. Cyprus, France, Greece, Italy, Portugal, Spain) (DM, 2003; NP, 2005; RD, 2007; CMD, 2011; JORF, 2014; KDP, 2015) are based on the referenced guidelines and regulations cited above, all of them including several modifications for some uses.

Justification of the stringency of the quality criteria

The assumed tolerable health risk for the proposed quality criteria is based on the WHO Guidelines for Drinking Water Quality (WHO, 2004 and 2011), which establishes the tolerable burden of disease (caused by either a chemical or an infectious agent) as an upper limit of 10^{-6} Disability Adjusted Life Years (DALYs) per person per year. Although the management of health risks is context specific, the WHO guidelines consider that the overall levels of health protection should be comparable for different water-related exposures (i.e. drinking water, reclaimed water irrigation of foods).

In the context of reclaimed water use, since food crops irrigated with reclaimed water, especially those eaten uncooked, are also expected to be as safe as drinking water by those who eat them, the same tolerable level of risk of 10^{-6} DALYs is proposed by the WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater (WHO, 2006). It is noteworthy that the analogue tolerable risk has been also applied under the Directive (98/83/EC) of water for human consumption (Drinking Water Directive (DWD)).

Justification of exclusion of compounds of emerging concern

With the advance of analytical techniques a growing number of chemical compounds, which are not commonly regulated, have been detected in drinking water, wastewater, or the aquatic environment, generally at very low levels. This broad group of chemicals is termed Compounds of Emerging Concern (CECs). The concern is due to either a knowledge gap about the relationship of the substances' concentrations and possible (eco)toxicological effects

– usually due to chronic exposure, or the lack of understanding how such substances interact as chemical mixture. CECs are not necessarily new compounds and might have been present in the environment for a longer time, while their presence and significance are only recognised now. At EU-level, currently there is no precise relationship between the occurrences and levels of CECs in (treated) wastewater and the acceptable level in the aquatic environment. It is also commonly accepted that today a frequent monitoring for every potential chemical substance is neither feasible nor plausible.

In general, most of the few studies available have shown that the uptake, translocation and the accumulation of a wide range of emerging chemicals in crop tissues is overall low and does not pose significant risks for public health. The risks related to the direct use of pesticides applied to crops appear to be of greater importance. While a broad range of publications have investigated the occurrence of CECs, the role of CECs in agricultural systems is poorly investigated, reason for which OECD investigated the issue through a high-level expert team (OECD 2012). The report carefully assessed the state-of-the-art and identified measures for risk mitigation. The report did not identify or mention the use of treated wastewater for agricultural irrigation as a significant entry pathway. The same study concluded that the agricultural use of biosolids such as treated or untreated manure from pig, poultry or cattle is a significantly greater reservoir for plant uptake of CECs than irrigation with treated wastewater.

Although a great deal of information indicate that domestic wastewater is amongst a likely major environmental reservoirs for antimicrobial resistance (AMR), but it was concluded that this has to be addressed in a more general context of wastewater sanitation rather than specifically for reuse schemes. This is underpinned by evidence indicating that water reuse for irrigation leads to a removal of AMR, since most of the resistant bacteria cannot survive in the receiving soils.

It was therefore concluded that specific limits for CECs would create at present an unjustified burden of control. However, the evolution and improvement of the current knowledge base, both regarding the effects of CECs, but also regarding the introduction of novel measurement techniques grasping better the chemical reality stemming from a mixture of chemicals, e.g. through the use of novel bioanalytical techniques require to be monitored regularly as to be able to take account of scientific developments.

Sensitivity analysis

The scope of the sensitive analysis is to ensure whether a higher or lower value for a selected parameter leads actually to a change of the result. The proposed minimum requirements rely on a series of key parameters commonly used to define the quality of wastewater before and after various treatments. The selected key parameters must hence ensure that a.) together they cover the risk framework and b.) they are as stringent as necessary, but not more.

The quality requirements considered have been established following a risk management approach. Although no specific risk assessment with European data was performed the selection of the minimum quality requirements is related to existing water reuse guidelines and MS regulations, and on the health and environmental risks considered by those.

Besides a series of recommendations, the minimum quality requirements provide specific limit values for *E. coli* (as an microbiological indicator), biological oxygen demand (a surrogate for the degree of organic pollution), total suspended solids (TSS) and turbidity (both describing efficiency of water filtration applied). These parameters are commonly used to describe the degree of cleanness of treated wastewater after a primary and secondary treatment and are commonly used in national regulations and guidelines.

For *E.coli*, the parametric values for the best reclaimed water quality on food crops consumed raw set in Cyprus, France, Greece, Italy and Spain range from ≤5 cfu/100 ml to ≤250 cfu/100 ml. The proposed minimum requirement of ≤10 cfu/100 ml is hence in line with existing national standards, while aiming at a EU high quality for this most critical application of food crops consumed raw.

For TSS a minimum quality criterion of ≤10 mg/l is proposed, which is in line with levels already established in Cyprus, Greece and Italy and slightly more stringent than the limits established in France (≤15 mg/l), Portugal (≤60 mg/l) and Spain (≤20 mg/l).

For the complementary parameter of turbidity only Greece and Spain have established thresholds, which are in line with the proposed minimum of 5 NTU.

The proposed subsequent reclaimed water quality classes are then in line with the requirements stemming from the Urban Wastewater Treatment Directive for TSS, BOD and turbidity and follow a logarithmic scale for *E. coli*.

These universal parameters are in line with those thresholds implemented already in some countries with a proven water reuse experience, but are sufficiently high to aim at an overall necessary standard at EU level. The level of stringency can hence be seen as appropriate and as protective if the respective risk management framework is applied properly.

Annex 8 - Assessment of impacts on Research and Innovation

DG RTD Initiative on Integration of the Innovation Principle into New EU Policy Initiatives: Application of R&I Tool for Better Regulation

Report from the Workshop on "Water Reuse and Research and Innovation"

31 May 2017

1. INTRODUCTION

The European Commission is preparing a new legislative instrument on minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge. This is one of several policy measures to stimulate reuse of reclaimed water in water management, industry, agriculture and municipal sectors[1]. Water reuse is an integral element of EU Circular Economy, Water and Climate Change Adaptation policies as it can help protect natural resources, bring economic savings and alleviate water scarcity problems.

In the context of the Better Regulation policy of the European Commission the Directorate-General for Research and Innovation (DG RTD) intends to scrutinise all new policy proposals for their impact on innovation. To this end it developed the R&I Tool for Better regulation – a guidance on how to assess the impact on innovation and how to improve legislative proposals so the potential impact on innovation is positive rather than negative.

This report is the result of the application of the R&I Tool to the new policy initiative on water reuse in the impact assessment phase. The objective is to extend the usual assessment of economic, social and environmental impacts to include the impact on innovation. It is expected that this will contribute to the sound selection of preferred policy options and provide recommendations on how the policy should be formulated so that it will not hamper innovation but rather stimulate innovation as much as possible.

It should be noted that this application of the R&I tool is the first pilot application and thus a learning exercise both for DG RTD and the lead service (in this case DG ENV). The methodological approach includes a wider scope of policy options than the options assessed in the Impact Assessment report as the exact options to be included in the impact assessment were not yet defined when the methodology was decided. Moreover, DG RTD intended to test the R&I Tool on a wider range of generic policy options and obtain experience on how practical and useful the R&I tool is.

[1] For more information on water reuse policy initiative please see the document "Closing the loop - An EU action plan for the Circular Economy", COM/2015/0614

Once the lead service develops a legislative draft this report may be followed by recommendations on legislative techniques that can make the legislative proposal more innovation friendly.

2. PROCESS

The methodology for this assessment is based on the application of the R&I Tool for Better Regulation and, in particular, of the set of questions on different aspects of innovation included in the Tool. These questions were presented to experts in the water reuse field to gather their expert opinion, compile and organise it with the aim to provide as an assessment of innovation friendliness as comprehensive as possible.

In order to obtain expert opinions in the short time period available for this exercise, DG RTD organised a workshop with water reuse experts on 31 May 2017. The invited experts were selected from the projects financed by the EU Framework Programme for Research and Innovation (these include both ongoing projects financed by the Horizon 2020 as well as finished projects financed from the 6^{th} and 7^{th} Framework programmes). Thirteen experts accepted the invitation and took part in the workshop.

The experts have provided their opinions both orally during the workshop and through written input after the workshop. The input received from the experts has been compiled and transformed into this report. The draft report was sent back to experts to verify that it accurately represents their opinion.

Policy options that have been assessed

When the methods of this assessment were developed and the workshop was organised, the options as they are formulated in the Impact Assessment report were not yet known. Therefore, the options discussed at the workshop were a combination of generic options that are applicable for all EU policy initiatives and specific options corresponding to possible elements of policy as identified by preparatory studies (e.g. in the Initial Impact Assessment and the JRC study) and discussed in the Impact Assessment Steering Group meetings. It can be concluded that the main options assessed below correspond to the main options of the Impact Assessment Report. These options included:

- **mandatory measures**, i.e. Member States are obliged to comply with the legal requirements stipulated in the law; or
- **voluntary measures**, i.e. Member States are advised or incentivised to implement certain measures but are not strictly obliged to do so. They usually take the form of EU recommendations, guidance or communications.

Specific options:

1. **Targets** for Member States, e.g. what proportion of treated waste water should be reclaimed for further reuse;
2. Measures to **prevent trade barriers** (harmonization of rules or mutual recognition of national rules);

3. **Limit values for control of hazardous substances in the reclaimed water for reuse**. These can be set to protect **either public health**, e.g. microbiological pathogens or hazardous substances that may enter food chain, or **prevent environmental damage**, e.g. overload of nutrients that may cause eutrophication of surface water bodies, degradation of soil or pollution by hazardous substances that have negative impact on terrestrial and aquatic ecosystems.
4. Measures to address **public health risks** by the application of risk management systems (public health risk management requirements);
5. Measures to address **environmental risks** by risk management systems (environmental risk management requirements);
6. **Governance and economic aspects**, i.e. who is responsible for delivery of the requirements and who pays for what and how much;
7. **Technology**, e.g. is any particular technology or technique required (explicitly or implicitly).

At the workshop the above specific options were discussed first and experts selected the most relevant ones. As the result the workshop focused mainly on options 3, 4 and 5 and the links among them. Option 1 was immediately eliminated as not acceptable at the EU level and option 2 was included as an overarching component of options 3 and 4. Options 6 and 7 have been also assessed but were commented by experts.

An analysis of the impact on innovation of these options is presented below.

3. ANALYSIS ON THE IMPACT TO RESEARCH AND INNOVATION

3.1. Option – EU Minimum quality requirements (limit values) + additional MS requirements

3.1.1 Voluntary EU minimum quality requirements (limit values set for selected water quality parameters) reflect the current fragmented situation in the EU. They will not drive or stimulate innovation that would have EU-wide impacts.

Voluntary minimum requirements will lead to:

- Fragmentation of the setting of parameters and their limit values among different countries;
- A water reuse market governed by local drivers and local initiatives of end-users;
- Specialised, almost tailor-made local technological products that are not seen as replicable elsewhere;
- Different technological products for every different application;
- Different quality limit values that will create difficulties to compare research results and innovative solutions. It will create obstacles for data bases structures;
- Disintegration and sectionalisation of R&D infrastructures;
- A limited pool of choices and R&D investment opportunities;
- Less efficiency, efficacy and competitiveness of the industry;
- Possibly negative cooperation between public and corporate R&D; and
- Less cooperation for innovative solutions and EU-wide incentives to facilitate and enhance water reuse.

Voluntary limit requirements may be accompanied with the EU guidance but the experts were not convinced that it could have an added value for R&I. For example, the updated voluntary WHO water reuse guidance introduced in 2006 did not stimulate any development of new water reuse projects in the EU.

3.1.2 Mandatory EU minimum quality requirements (limit values)

Mandatory EU minimum quality requirements are seen as innovation-friendly if certain conditions, such as the balanced scope of water quality parameters and stringency of limit values, are met:

- This policy option can stimulate and drive R&I in technologies and solutions that will help to reach the limit values of defined parameters. They will boost R&I at all phases driven by the needs to demonstrate technical performance, efficiency and reliability of conventional and new technologies (filtration, disinfection, membranes, advanced oxidation, etc.), economic viability of water reuse projects, and social and environmental benefits.
- New and innovative ways of monitoring will be stimulated, in particular online (continuous) monitoring, development of new microbiological and chemical indicators. New analytical methods will be developed for instance for pathogens (based on RNA-ribonucleic acid analysis) or effect based analysis for chemicals (bioassays). Setting standards for online monitoring techniques will produce an incentive to bring more R&D results to the market.
- Minimum quality requirements will establish a stable market and speed up application of innovative solutions and exploiting existing results;
- The harmonization of quality requirements (parameters and limit values) and procedures will provide innovative companies the opportunity to scale up.
- This option will reduce compliance costs and time for the development of innovative technologies/solutions due to the need to meet the challenges within the deadlines set by the legislation.
- It will positively affect cooperation between public and corporate R&D throughout Europe. Large demonstration projects applying results of public and private research will be necessary to validate water reuse schemes' performances;
- It will also stimulate social innovation, better cooperation between stakeholders, multidisciplinary research, improved public education, integrated and holistic approach to water resource management, sustainable development and the application of the circular economy concept in the water sector.

Experts supported these impacts by the following comments:

The above-mentioned positive impacts will only realise if a balanced scope of parameters and appropriate stringency of limit values is found. If too many parameters and very stringent limit values become obligatory this can discourage application of water reuse and the driving effect for innovation would disappear. If these are too low and easy to achieve with the conventional technology it will not provide additional drivers for innovation compared to the current situation. On setting the balanced scope of parameters and stringency of limit values the following comments were made:

- The balanced scope of parameters related to health concerns could be based on FAO recommendations and the recent DG SANTE guidance document[2] (the guidance document to support the implementation of Regulation 852/2004). Parameters of environmental concern should be identified on a case by case basis and adopted at local level for the local water reuse schemes in specific local environmental conditions related to soil and local water bodies.
- The experts expect that the majority of new water reuse projects will start at local level as at small scale – on average 500-3000 m3/day – and end-users and local municipalities will not be able to afford excessively expensive and complex technology and monitoring systems.
- On the other hand the monitoring requirements should be based on advanced scientific knowledge. Traditional monitoring frequencies (once per week or per month) are hampering the development and application of new smart sampling strategies and thus new innovative solutions[3] while preventing the application of innovative online monitoring technologies. At the same time the traditional monitoring based on low frequency sampling and limited laboratory analysis is not sufficient to ensure a high level of health protection and provide public confidence in reuse practices. Also, a European Innovation Partnership for Water Action Group RTWQM[4] survey concluded that the current standard water sampling strategies not properly representing the real status of the water bodies and the efficacy of treatment processes[5].
- Quality requirements for additional parameters should be left at the discretion of each MS or regional and local authorities to allow for the consideration of local conditions. Additional prevention measures, such as those recommended by WHO guidelines and in the ISO 16075 standard, could be included, for water categories with lower quality depending on health risks on a case to case basis as part of a risk management plan.

Actions recommended:

The positive effects stated above will only be achieved if the legislative proposal succeeds in setting a balanced scope of water quality parameters and the appropriate stringency of limit values. Experts suggested that the parameters and limit values should be reviewed on a periodic basis according to the challenges and the development of the scientific knowledge.

3.2. OPTION – MEASURES TO ADDRESS REAL OR PERCEIVED PUBLIC HEALTH RISKS (RISK MANAGEMENT REQUIREMENTS)

The experts concluded that in general, the promotion of the risk management approach (whether mandatory or voluntary at EU level but assuming that risk management will be required at national, regional or local level) will have a positive impact on innovation:

- The application of a health risk management at any scale will facilitate the introduction of future innovative solutions to address the risks identified. These solutions will be cost-

[2] SANTE/10470/2016 – Guidance Document on Addressing microbiological risks in fresh fruits and vegetables at primary production through good hygiene
[3] Example: see AQUABIO and AQUATRACK in http://r3water.eu/techniques-for-reuse-of-water/
[4] EIP Water AG 100 – Real Time Water Quality Monitoring
[5] https://www.eip-water.eu/sites/default/files/AG100%20RTWQM%20WaterReuse-ConceptNote-v2.pdf

effective as they reduce the need for monitoring and avoid unnecessary or inefficient measures.
- Health risk management naturally stimulates multi-disciplinary scientific research and brings together specialists in microbiology, chemistry, ecology, IT and other areas.

The main difference between the voluntary and mandatory approach at EU level is in the scale of application of new solutions with all implications on economy of scale, sharing of data and knowledge, building of research infrastructure and collaboration between different actors.

3.2.1 Risk management approach addressing health issues (RMA-H) – voluntary measures:

Voluntary RMA-H measures have a very limited potential to drive innovation.

- This option will result in fragmented local applications of different risk management systems and will not drive the generation of new RMA-H ideas at EU level.
- The cooperation on R&I will be limited only to the areas where the same risk management requirements exist.
- These measures will lead to the fragmentation of information and knowledge, to localised data and consequently to small-scale innovation development, applicable only for a certain area.
- It will negatively affect the incentives for companies to scale up in Europe due to the limited area of application of RMA at local level.
- The overall compliance costs and time for the development of innovative RMA-H solutions will increase.

However, experts pointed out that despite the fragmented and localised development of innovation in the case of voluntary approach (assuming the RMA is promoted at MS or regional level) there may be a positive impact on innovation:

- RMA-H application at any scale will facilitate the introduction of future innovative solutions to address the risks identified and these solutions can be cost effective as they reduce the need for monitoring and unnecessary of inefficient measures.
- RMA-H naturally stimulate multi-disciplinary scientific research and bring together specialists in microbiology, chemistry, ecology, IT and other areas.

3.2.2 Risk management approach addressing health issues (RMA-H) – mandatory measures:

Mandatory RMA-H measures will have a positive impact on the development and scale-up of innovative approaches to health risk management and solutions to address the risks related to water reuse. They will:

- Facilitate the realisation of the methodology for the development of Water Safety Plans for each water reuse scheme, e.g. as already demonstrated by the DEMOWARE project[6];
- Ensure a strong cooperation and a substantial participation of industrial partners and end-users, enhancing public and corporate R&D to develop leading-edge EU innovative health risk management tools;
- Stimulate multidisciplinary scientific research, such as ecotoxicology, chemistry, microbiology, parasitology, and develop a holistic approach to water reuse risks;
- Positively affect innovation dynamics of specific markets such as those for treatment technologies, monitoring equipment, analytical techniques for identification and detection of relevant pollutants;
- Facilitate spreading knowledge and information leading to well-informed stakeholders which are able to make sound decisions. It is expected that risk management measures will be better implemented and more effective. The cost of risk management systems, and of risk prevention measures and technologies, will be reduced due to the efficiencies related to the scale. Also administrative costs can be reduced due to harmonisation and standardisation of RMA procedures;
- Enhance the development of more robust and less risky technologies that will be further promoted by regularly evaluating the risks of water reuse;
- Facilitate the adaptation of R+D infrastructures to the new approach;
- Produce great potential for companies to scale up, and to apply large business models which will ensure the successful commercialization of the systems developed. At the same time it will create markets for highly specialized SMEs;
- The dynamic and repetitive character of RMA will allow introducing new findings and innovations in the successive revisions of the Water Safety Plans for the specific water reuse schema in a more dynamic way.

However, a mandatory RMA-H may also:

- Create administrative burdens and increase costs related to initial testing, piloting or demonstrating RMA-H approach;

Experts pointed out that the positive effects above will materialize only if the mandatory requirements for RMA are sensible and balanced and do not entail high costs. Setting these requirements will also include the decision whether qualitative or quantitative methods of RMA will be promoted. Some experts were of the opinion that the RMA should be based on the qualitative approach such as the WHO Water Reuse Safety Plans. The EU regulation could stimulate the development of a methodology how such plans should be constructed and applied including practical tools. According to these experts the quantitative microbial or chemical risk assessment is neither applicable nor affordable for each water reuse project and is characterised by a number of important disadvantages such as the lack of scientific evidence and consensus on the assumptions on the choice of representative pathogens, its infection dose, vulnerability of the population, etc.

[6] http://demoware.eu/en/results/deliverables. Deliverables D3.1 - "Appropriate and user friendly methodologies for RA_LCA_WFP" and D3.2 – "Show case of the environmental benefits and risk assessment of reuse schemes", are of a special interest.

Actions recommended:

The positive effects described above will again depend on a proper definition of the RMA requirements (e.g. RMA methodology). An assessment of feasibility and costs of the preferred methodologies should be performed to ensure that the requirements do not hamper the application of the RMA. The legislation should be dynamic and reflect R&D progress while taking into consideration future assessments.

3.3. OPTION – MEASURES TO ADDRESS REAL OR PERCEIVED ENVIRONMENTAL RISKS (RISK MANAGEMENT REQUIREMENTS)

The application of environmental risk management in relation to water reuse, both on voluntary and mandatory basis, will stimulate multi-disciplinary scientific research reacting to the need to assess environmental pressures (on receiving water bodies and soil) and the vulnerability of ecosystems, to set requirements for quality of reclaimed water and monitoring, and define mitigation measures.

The optimal way to manage the environmental risks related to water reuse will very much depend on the local conditions, including hydrological regime and characteristics of local water bodies, soil composition, climate, local ecosystems, etc. It is therefore difficult to define the best risk management approach that would be equally effective at all locations across Europe. A mandatory system to manage environmental risks of water reuse can only be prescribed in general terms with a lot of discretion for action at local level. Therefore the mandatory and voluntary approaches may not differ significantly under the assumption that the voluntary approach will mean that national, regional or local authorities will mandate or effectively promote risk management at local level.

3.3.1 Risk management approach addressing environmental protection (RMA-E) – voluntary measures:

The voluntary RMA-E corresponds to a large extent to the current situation and therefore the impact on innovation and research is limited.

Nevertheless, RMA-E voluntary measures would have an impact on the generation of new ideas and their adaptation and application, because:

- The relation between wastewater treatment, disposal and reuse would arise and require new ways to manage waste and reclaimed water disposal;
- There will be a need to share knowledge in order to develop and apply risk management tools;
- The basic knowledge will likely be generated in public research institutions, while practical application tends to be performed at the corporate actors.
- Risk management approaches create new objectives and lead to new ways in the establishing of R&D infrastructures for water reuse.
- If properly performed, innovation in RMA-E field would reduce costs (less analysis, fewer costly mistakes) and save time.

However, voluntary RMA-E

- May lead to small and scattered areas of different standard application and may present obstacles for any pertinent development;
- Will not create incentives for companies to scale up in Europe, due to limited area of application, since these differences in requirements may lead to unacceptable costs;
- May limit cooperation only to the areas where the same standards exist. In other areas different needs call for different solutions and thus localise again the circulation of data and ideas;
- May produce higher costs due to local specialised RMA-E approaches and focus on particular technologies and measures.
- The voluntary approach will likely not lead to improving the capacity of small private users of reclaimed waters (e.g. farmers) to apply risk management in their operations. It will only be larger companies and public bodies who will have the capacity to develop and properly apply environmental risk management.

3.3.2 Risk management approach addressing environmental protection – mandatory measures:

Mandatory RMA-E will enhance R&I:

- It will drive the generation of new risk assessment solutions, their adaptation and application and it will boost the industrial base;
- It will enhance the R&D of more robust technologies and will be greatly promoted together with the evaluation of the acceptability of reuse and recycling options to end-users.
- It will develop capacity and methods for assessing, mapping and valuing multiple water reuse and recycling technologies, across space and time for informed integrated management
- It prevents both over- and under-engineering solutions;
- It will ensure a substantial participation of industrial partners and end-users, enhancing public and corporate R&D;
- It will affect the application of innovation dynamics of specific water reuse market fostering innovative solutions in the area of monitoring, new analytical techniques, and bioassays at the same time coinciding with the advancement of new technologies for water treatment for reuse.
- Via multi-disciplinary scientific research it will stimulate social equity, economic efficiency, and environmental integrity.
- It will contribute to the thriving EU economic water reuse sector producing a great potential for the companies to scale up applying large-scale business models which will ensure the successful commercialisation;
- A unified regulatory environment having similarly assessed the risks and opportunities across Europe will then correspondingly boost R&D investments and could help maintain the leading position of the EU in the field of research on emerging substances and bioassays.

- Across Europe, it will result in lowered costs for risk assessment and for risk mitigation measures.

However, if the mandatory RMA-E is too complicated it could:

- Make the implementation more expensive and slow down the development of innovative technologies and solutions of water reuse schemes; and
- Increase administrative burden.

Actions recommended:

Again, positive effects will only be achieved if the measures proposed will be defined in a balanced and adequate way in order to avoid excessive administrative burden or costs. The mandatory approach should still give room for a wide range of solutions that make use of local structures and resources, as long as they prevent the environmental risks for the specific case.

Introduction of mandatory risk management in relation to water reuse should be consistent with the planned revision of the Urban Waste Water Treatment Directive that may introduce similar requirements for the management of risks related to the discharge of treated wastewater to the environment.

3.4. ANALYSIS OF IMPACTS OF POSSIBLE REQUIREMENTS ON GOVERNANCE AND ECONOMIC ASPECTS AND ON TECHNOLOGY

3.4.1 Governance and economic aspects

No specific options for governance set-up were proposed but the experts discussed in general terms the impact of governance of water reuse schemes[7] on innovation:

- One of the main market barriers for water reuse is the fragmentation of the urban water cycle. The management of the water value chain is often distributed among different actors, resulting in a lack of a holistic view and poor synergies. Individual actors hesitate to innovate until other stakeholders do.
- Any mandatory EU policy should include a clarification of the role and responsibility for meeting the mandatory requirements of each actor involved (producer of reclaimed water, end user, reuse management authority), the permitting procedure and monitoring programs. Assigning responsibility to these actors can motivate them to look for effective solutions including innovative and cost effective ways to meet the mandatory requirements.
- There is a need for some degree of flexibility in allocating the responsibility because mandating exclusive responsibility either to “point of use” or “point of treatment” might hamper the development of alternative innovative business models.

[7] A water reuse scheme is a system consisting of UWWTP, distribution system and the system for application of reclaimed water for irrigation or groundwater recharge.

- Although the point of treatment is well defined and allows creating specific rules and regulations, the definition of point of use is not always clear and it remains difficult to comply with requirements due to the lack of real control of reclaimed water quality after the point of treatment. Therefore new solutions to coordinate the reclaimed water quality between the point of treatment and the point of use are needed.
- New water reuse schemes are hampered by several economic factors that impede a broader adoption through the EU, including:
  - doubts about the economic sustainability of the current business models; and
  - pricing strategies.
- Subsidising current technological solutions might hamper the development of more cost-effective innovative solutions. Cost-effective innovation relies on users paying the true costs of resources. On the other hand to improve the economic viability of water reuse schemes economic stimuli for actors may be needed, e.g. in the form of sharing the costs and benefits between the utility that provides the reclaimed water, distribution system and final users (farmers). For example, it was indicated that innovative solutions based on "win-win" approaches which will not rely on the farmers paying all reclamation and reuse costs should be considered according to the FAO book issued in 2010 on the economy of reuse.
- There is still need for R&I on the economic sustainability of the reclaimed water services, business models and pricing strategies.
- In order to improve public trust in use of reclaimed waste water the regulatory and risk management measures should be accompanied with public awareness and communication measures.

3.4.2 Technology

No specific options for technology requirements were proposed but the experts discussed in general terms the impact of setting technology requirements on innovation:

- The Urban Wastewater Treatment Directive contributed to a high growth of R&I on new treatment technologies, in particular for nutrient removal. The same effect on R&I could be expected with the new Water Reuse legislation.
- The measure should not be limited to a parametric approach (meeting output requirements only) but it should be coupled with defining minimum suitable treatment processes. These recommended processes should be indicative, leaving room for novel alternatives (such as green and/or grey infrastructures) achieving similar results.
- Promoting strongly specific established technologies might hamper the development of new more effective technologies.
- The choice of the appropriate reuse and recycling technology is the most important step in planning an effective and efficient water reuse system. It is the key element in decreasing the potential risk comprising technical, economic, environmental and social parameters. In order to choose a technology pertinent for an area or region, it is possible to build on successful results of certain European projects in this domain.
- The problem is not the lack of treatment techniques and technologies, but rather how such schemes may become more efficient and implementable in conjunction with integrated water resources management. Currently there are no decision-making tools available to enable decision-makers and water resource users to view, assess and value different reuse

and recycling technologies and approaches, and consider their respective advantages and disadvantages.

- New more efficient and reliable treatment technologies are being developed. Membrane technologies, such as MBR, UF, MF, etc. are a proven and efficient barrier to pathogens, but their investment and O&M costs are very high. In addition to the requirement for affordable cost and easy maintenance, the new treatment technologies for reclamation and irrigation should be adapted for intermittent operation only during the period of irrigation, which is not the case of the majority of the available technologies nowadays. For example, the MARSOL (FP7) project[8] demonstrated an application of a sound, safe and sustainable strategy of Managed Aquifer Recharge (MAR) and shown that it can be applied with great confidence. The MAR approach demonstrated that the use of reclaimed water and other alternative water sources in MAR can optimize water resources management in times of water shortage.
- The further development of optimal technologies for the main categories of water reuse application still needs significant R&I efforts and in-situ demonstration. Due to the small scale of the majority of water reuse projects for irrigation and aquifer recharge the investment in the development limited.
- Monitoring, and in particular online monitoring of reclaimed water quality, presents major challenges. Affordable and easy to maintain sensors should be developed for monitoring of conventional parameters (turbidity, chlorine residual, conductivity, etc.), microbiological parameters (E. coli, coliphages, etc.) and emerging parameters and pathogens including surrogate monitoring and methods for broad spectrum analysis.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions and Recommendations concerning the new legislative instrument on minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge

In addition to the assessments as set out in section 3, experts also drew the following conclusions and recommendations:

- The EU has the potential to become a leader in the water reuse field, instead of following foreign developments. It would contribute to the EU competitiveness, innovation, and global technological leadership.
- For the development of an efficient and widely applicable European legislation in the field of water reuse three criteria should be met: effectiveness from the perspective of the protection of public health and the environment, the affordability of practical application and the implementation of the latest advance in science and practice.
- There is a need to have an innovation-friendly legislation. Minimum quality requirements for reclaimed water are likely to incentivise further innovation in this field. However too stringent quality requirements can be counterproductive and kill water reuse practice and related market opportunities.

[8] www.marsol.eu / www.eip-water.eu/MAR_Solutions, with the application of MAR in eight demonstration sites in six countries around the Mediterranean (Portugal, Spain, Italy, Greece, Malta, Israel)

- A combination of limit values for selected quality parameters and risk management is the way to go. The decision which aspects of reclaimed water quality will be regulated through parametric limit values and which well be subject of risk management will be critical to the effectiveness and efficiency of the legislation.
- Limit values and the scope of parameters should be dynamic and allow for adaptation to progress in scientific knowledge and technological development.
- Risk management should be effectively promoted by the new legislation. The legislation should set essential requirements of risk management system for water reuse but the application and adaptation to the local conditions has to be left to local actors.
- The discussion also pointed to a communication challenge and experts recommend using the terms "reclaimed water" rather than "treated waste water" which are too negatively connoted.
- Due to the lack of information on health or environmental risks of the existing water reuse projects in Europe and worldwide it will be difficult to establish a realistic baseline for evaluation of the impacts of this initiative. To retrieve reliable and up-to-date information from existing and planned water reuse schemes new R&I projects should be considered.

Specific recommendation for drafting the legislative text:

- Introduce flexible and dynamic requirements for regulating selected parameters and their limit values, e.g. through the regular review mechanism;
- Set essential requirements for RMA-H and RMA-E and dynamic requirements for specific requirements, e.g. through the review mechanism;
- Set the dynamic minimum technology requirements and foresee their review to adapt them to technological development;
- Set the dynamic monitoring requirements that will open the possibility for the online monitoring techniques provided that the online method has proven its equivalency e.g. through Environmental Technology Verification (ETV). Remove suboptimal monitoring methods in the future, e.g. by a sunset clause;
- Establish the requirement for a Life-Cycle Assessment (LCA) for each water reuse scheme and in particular the requirement to demonstrate environmental benefits by providing Key Performance Indicators (KPI).

4.2. Broader Policy Recommendations

In addition to the assessment of options for the future EU legislative instruments analysed for their innovation friendliness, the experts made, in the course of discussion, the following general recommendations on the broader policy context in which this new legislative will be implemented:

- When addressing water reuse a holistic approach is needed. The whole value chain of water reuse should be considered from a systemic point of view, looking beyond environmental, health and trade aspects.

- Any water reuse initiative needs to be also put in the context of the interaction of water policy with other policy areas. For example, the relationship water-energy (nexus) should also be considered.
- The present water reuse legislative initiative focuses on the use of reclaimed water in agriculture and groundwater recharge. In the future it will be equally important to address water reuse for other purposes such as urban uses, industrial uses, etc.
- Water reuse legislation will interact with other legislative instruments such as the Urban Waste Water Directive and the Environmental Quality Standards Directive. Water reuse needs to be considered in the upcoming review of different pieces of EU water legislation.
- Emerging pollutants should be regulated at appropriate level. Parameters like antibiotic resistance, microplastics, nanoparticles, etc. are not of specific concern for water reuse and should be identified in the context of other, more global EU legislation, e.g. the Water Framework Directive and its daughter directives.
- To support the implementation of this new EU legislation, there is a need to develop an EU network or a platform to valorise and exploit European R&I projects' results and to facilitate practical application of projects as currently their uptake and upscaling is very low.

Annex 9 - Assessment of territorial impacts[9]

Territorial Impact Assessment Report

Development of Minimum Quality Requirements for Reused Water in Agricultural Irrigation and Aquifer Recharge

Based on workshop carried out using ESPON TIA tool

24/04/2017

This territorial impact assessment report is the outcome of an expert workshop organised by Directorate General of Regional and Urban Policy (DG REGIO) in collaboration with Directorate General for Environment (DG ENV) within the framework of the Better Regulation, applying tool No. 29 from the Better Regulation toolbox, in particular the TIA tool of the ESPON 2020 Cooperation Programme, partly financed by the European Regional Development Fund.

The ESPON TIA Tool is designed to support the quantitative assessment of potential territorial impacts according to the Better Regulation guidelines. It is an interactive web application that can be used to support policy makers and practitioners with identifying, ex-ante, potential territorial impacts of new EU Legislations, Policies and Directives (LPDs).

This report documents results of the territorial impact assessment expert workshop on the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge. It serves for information purposes only. This report and the maps represent views and experiences of the participants of the workshop. It is meant to be used for decision support only and does not necessarily reflect the opinion of the members of the ESPON 2020 Monitoring Committee as well as DG REGIO and DG ENV.

The ESPON EGTC is the Single Beneficiary of the ESPON 2020 Cooperation Programme. The Single Operation within the programme is implemented by the ESPON EGTC and co-financed by the European Regional Development Fund, the EU Member States and the Partner States, Iceland, Liechtenstein, Norway and Switzerland.

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[9] The TIA has been completed before the JRC modelling report (Annex 4), therefore there could be some differences in these reports in particular as regards the data availability.

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Institutions and organisations involved in the territorial impact assessment on the Development of Minimum Quality Requirements for Reused Water in Agricultural Irrigation and Aquifer Recharge

European Commission (DG REGIO, DG ENV, DG SANTE, DG AGRI); European Committee of the Regions, ESPON EGTC.

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Information on ESPON and its projects can be found on www.espon.eu.

The web site provides the possibility to download and examine the most recent documents produced by finalised and ongoing ESPON projects.

This delivery exists only in an electronic version.

Contact: info@espon.eu

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Abbreviations

CoR	European Committee of the Regions
DG ENV	European Commission – Directorate General for Environment
DG REGIO	European Commission – Directorate General for Regional and Urban Policy
DG SANTE	European Commission – Directorate General for Health and Food Safety
EC	European Commission
ESPON	European Territorial Observatory Network
ETKC	European Territorial Knowledge Center
EU	European Union
GDP	Gross Domestic Product
GVA	Gross Value Added
IA	Impact Assessment
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Center
LPDs	Legislations, Policies and Directives
NATURA 2000	European ecological network aimed at promoting the conservation of natural sites and wildlife habitats while taking into account the economic, social and cultural needs and the particular regional and local features of each Member State. The network is the result of several directives on the conservation of habitats and species, adopted by the European Commission in the wake of the 1992 Rio Conference to deal with the worrying decline in biodiversity.
NUTS	Nomenclature des unites territoriales Common classification of territorial units for statistical purposes
ÖIR	Österreichisches Institut für Raumplanung/ÖIR GmbH
PM10	Particulate Matter
R&D	Research & Development
TIA	Territorial Impact Assessment
UK	United Kingdom
UWWTD	Urban Wastewater Treatment Directive
WWTP	Waste Water Treatment Plant

1 INTRODUCTION

1.1 The initiative of the Commission[10]

The European Commission is currently conducting an Impact Assessment (IA) for an EU initiative on the Development of Minimum Quality Requirements for Water Reuse in Agricultural Irrigation and Aquifer Recharge in order to contribute to reducing water scarcity. The IA focuses on the reuse of treated wastewater covered by the Directive 91/271/EEC concerning urban waste water treatment.

The only source of wastewater considered in this document is the wastewater covered by the Urban Wastewater Treatment Directive (UWWTD) (91/271/EEC). Thus, the wastewater considered is urban wastewater defined as domestic wastewater or the mixture of domestic wastewater with industrial wastewater and/or run-off rain water, according to Directive 91/271/EEC). The industrial wastewater considered is from the industrial sectors listed in Annex III of the UWWTD.

The health and environmental safety conditions under which wastewater may be reused are not specifically regulated at the EU level. There are no guidelines, regulations or good management practices defined at European Union (EU) level on water quality for water reuse purposes.

Because of an unclear regulatory framework across EU MS water reuse projects suffer from limited economic attractiveness. This creates difficulties for businesses operating cross-border and also limits the possibility to standardise technologies and benefit from economies of scale. The initiative of the EU Commission shall reduce these barriers and define under which conditions, minimum quality requirements, the use of reused water for agricultural irrigation and aquifer recharge is safe.

1.2 The approach of the ESPON TIA quick check

The concept of territorial impact assessment (TIA) aims at showing the regional differentiation of the impact of EU policies. The ESPON TIA Tool11 is an interactive web application that can be used to support policy makers and practitioners with identifying, ex-ante, potential territorial impacts of new EU legislations. The “ESPON TIA quick check” approach combines a workshop setting for identifying systemic relations between a policy and its territorial consequences with a set of indicators describing the sensitivity of European regions. It helps to steer an expert discussion about the potential territorial effects of an EU initiative by discussing all relevant indicators in a workshop setting. The results of the guided expert discussion are judgments about the potential territorial impact of an EU policy considering different thematic fields (economy, society, environment, governance) for a range of indicators. These results are fed into the ESPON TIA Quick Check web tool.

The web tool translates the combination of the expert judgments on exposure with the different sensitivity of regions into maps showing the potential territorial impact of EU policy

[10] The text of this chapter is based on the background paper for the TIA Workshop “Territorial Impact Assessment (TIA) on the on the Development of Minimum Quality Requirements for Water Reuse in Agricultural Irrigation and Aquifer Recharge” developed by the European Commission DG for Environment and DG for Regional and Urban Policy.

[11] https://www.espon.eu/main/Menu_ToolsandMaps/TIA/

on NUTS3 level. These maps serve as starting point for the further discussion of different impacts of a concrete EU policy on different regions. Consequently, the experts participating in the workshop provide an important input for this quick check on potential territorial effects of an EU initiative.

The workshop on the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge was held on 5 April 2017 in Brussels and brought together 24 experts representing different stakeholders, as e.g. national, regional and local authorities, NGOs and environmental institutions and European institutions such as the European Commission (DG REGIO, DG ENV, DG SANTE, DG AGRI) and the European Committee of the Regions.

Two moderators from the ÖIR, provided by ESPON, prepared and guided the workshop and handled the ESPON TIA tool.

Figure 1.1: Workshop Discussion

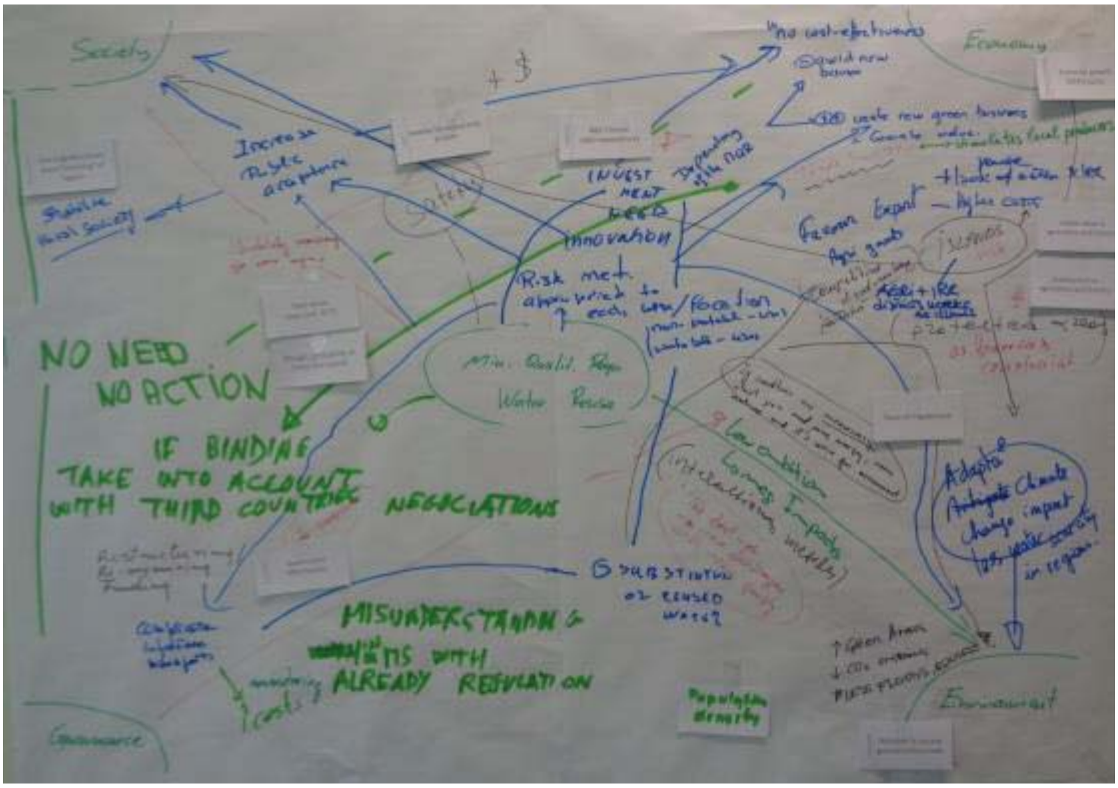
Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017 © ÖIR

2 THE ESPON TIA QUICK CHECK WORKSHOP – IDENTIFYING POTENTIAL EFFECTS ON THE TERRITORY

2.1 Identifying the effects considering economy, society, environment and governance related indicators – drafting a conceptual model

In the first step of the TIA workshop the participating experts discussed about the potential effects at regional level of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge. This discussion revealed potential territorial impacts of the development of minimum quality requirements in the fields of economy, society, environment and governance. The participants identified potential linkages between the different effects on regions including interdependencies and feed-back-loops between different effects (see figure below).

Figure 2.1: Workshop findings: Conceptual model of the regional effects of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017 © ÖIR

Environment

- The initiative could contribute to reduce the lack of water in those regions that are suffering from water scarcity. It could be one component to mitigate the effects of climate change connected to water scarcity and draughts.
- However, low ambitions of the initiative may lead to low environmental standards and consequently to negative environmental impacts, especially for ground water.
- The re-use of waste water may increase energy consumption.

- Additionally to the use of wastewater for agriculture irrigation, it could also be used for watering green areas in cities. This could increase the quality of live in **urban areas** and reduce CO_2 emissions.

Economy

- The reuse of water and the compliance with quality standards could require infrastructure investments. This could be a trade barrier compared with non-EU countries that do not foresee such quality standards. However, this could also be a chance for stimulating regional economic growth.
- Society
- The effect on employment can be twofold. On one hand there is the chance to increase employment in the “new green sectors”. On the other hand, when there is a lack of cost effectiveness, employment in agriculture sector could also decrease.
- The development of minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge could improve the public acceptance of reused water, which could create chances for development, especially in rural areas. Employment opportunities could contribute to stabilize rural society and reduce the decrease of population in rural areas.

Governance

- The public could interpret a complicate regulation with long lists linking different quality standards to different types of use of wastewater as a sign that the reuse of water is environmentally dangerous. This could cause a problem with its public acceptance.
- A complicated regulation could be too demanding for its implementation in islands considering the administrative capacity of the public services there. Consequently islands would have competitive disadvantages related to other regions.
- Some countries have quite high water quality standards, already. There is the fear that the new minimum quality requirements will get in conflict with existing standards and could reduce the level of quality in some MS.

2.2 Identifying the types of regions potentially affected

The ESPON TIA tool provides several regional typologies12 for analysis taking under consideration the types of territories mentioned in the Lisbon Treaty §174: urban/metropolitan regions; rural regions; sparsely populated regions; regions in industrial transition; cross-border regions; mountainous regions; islands and coastal regions. The experts agreed that in general all regions would be affected by the modification of this Commission initiative. Additionally, it was agreed that in some aspects especially rural regions could be affected differently.

2.3 Picturing the potential territorial effects through relevant indicators

In order to assess the potential effects pictured in the conceptual model suitable indicators need to be selected related to the economy, environment, society and governance parameters that the experts discussed. The availability of data for all NUTS 3 regions of the EU is posing certain limitations to indicators that can be used. From the available indicators that the

[12] https://www.espon.eu/main/Menu_ToolsandMaps/ESPONTypologies/index.html

ESPON TIA Quick Check web tool offers The experts chose the following indicators to describe the identified effects.

Indicators picturing environmental effects

- Agriculture depending on irrigated land
- Regions facing danger of droughts
- Regions facing heat waves
- Pollutants in soil and ground/surface water

Indicators picturing economic effects

- Economic growth
- R&D Climate
- Added value in agriculture and forestry

Indicators picturing societal effects

- Employment in agriculture and forestry
- Out-migration/brain drain/"shrinking" of regions
- Healthy life expectancy

Indicators picturing governance effects

- Government effectiveness

Data availability poses limitations to availability of indicators. The experts discussed that the set of provided indicators do not cover all effects that are caused by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge. Moreover, the set of indicators is too high level and too generic and the correlation between the initiative and the indicators are generally weak (e.g. there is only a weak link between indicator on R&D climate of a region and whether there are common quality standards for water reuse). Therefore the set of indicators do not mirror the supposed effects, but provide an indication only on effects.

Therefore, experts were called upon to identify a "wish list" of other indicators, which represent better the potential effects from the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge:

- population density
- amount of treated waste water
- output from agriculture from irrigated land
- employment in irrigation technologies
- water exploitation index at water basin level
- ratio crop water requirement and incoming water/satisfaction level
- indicators on water bodies status
- water prices
- energy balance for water reuse
- trade flows (agriculture)
- compliance on UWWTD

However, as data at NUTS 3 level on the above indicators aren't available, these indicators have not been used.

Nevertheless, DG REGIO and DG ENV will explore with EUROSTAT and with JRC in the framework of the Territorial Knowledge Centre how in the future this gap can be filled since these indicators and the necessary data will be important also for monitoring the effective implementation of the upcoming regulation.

2.4 Judging the intensity of the effects

The participants of the workshop were asked to estimate the effects deriving from the development of minimum quality requirements. They judged the effect on territorial welfare along the following scores:

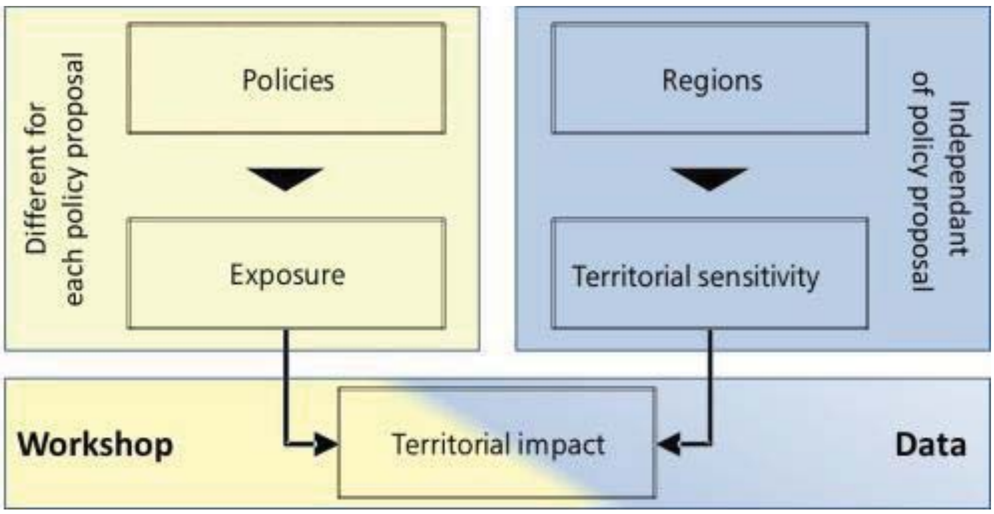
- ++ strong advantageous effect on territorial welfare (strong increase)
- +weak advantageous effect on territorial welfare (increase)
- O no effect/unknown effect/effect cannot be specified
- - weak disadvantageous effect on territorial welfare (decrease)
- - - strong disadvantageous effect on territorial welfare (strong decrease)

2.5 Calculating the potential "regional impact" – Combining the expert judgement with the regional sensitivity

The ESPON TIA Quick Check combines the expert judgement on the potential effect of the development of minimum quality requirements (exposure) with indicators picturing the sensitivity of regions resulting in maps showing a territorial differentiated impact. This approach is based on the vulnerability concept developed by the Intergovernmental Panel on Climate Change (IPCC). In this case, the effects deriving from a particular policy measure (exposure) are combined with the characteristics of a region (**territorial sensitivity**) to produce potential territorial impacts (cf. following figure).

- "Territorial Sensitivity" describes the baseline situation of the region according to its ability to cope with external effects. It is a characteristic of a region that can be described by different indicators independently of the topic analysed.
- "Exposure" describes the intensity of the potential effect caused by the development of minimum quality requirements on a specific indicator. It is the effect of the development of minimum quality requirements. Exposure illustrates the experts' judgement, i.e. the main findings of the expert discussion at the TIA workshop.

Figure 2.2: Exposure x territorial sensitivity = territorial impact



Source: ÖIR, 2015.

2.6 Mapping the potential territorial impact

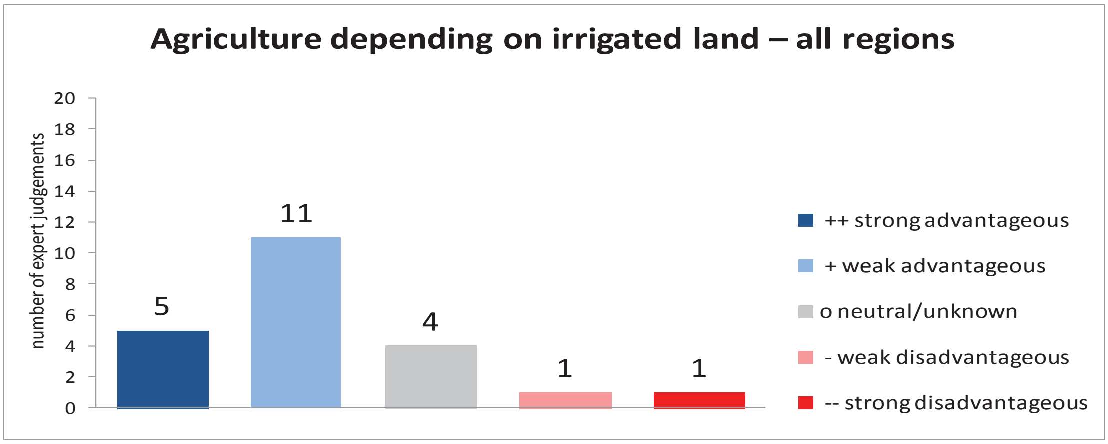
The result of the potential territorial impact assessment is presented in maps. The maps displayed below show the potential territorial impact based on a combination of the expert judgement on the exposure with the territorial sensitivity of a region, described by a indicator on NUTS3 level. Whereas expert judgement is a qualitative judgement (strong advantageous effect on territorial welfare/weak advantageous effect/no effect/weak disadvantageous effect/strong disadvantageous effect), the sensitivity is a quantitative indicator. (The detailed description is provided in the annex.).

3 RESULTS OF THE TIA QUICK CHECK: POTENTIAL TERRITORIAL IMPACT CONSIDERING ENVIRONMENT ASPECTS

3.1 The potential territorial impact based on agriculture depending on irrigated land

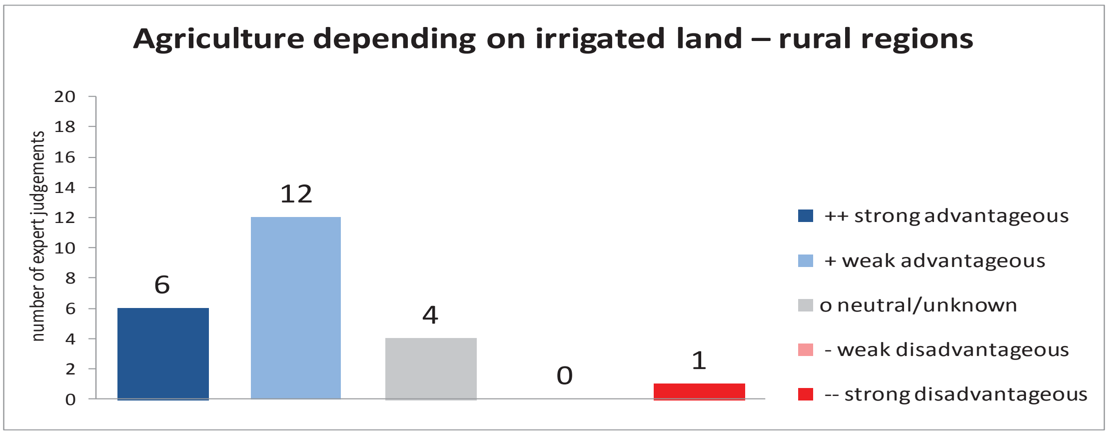
The experts agreed that the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge would definitely cause positive effects in all regions with agriculture depending on irrigated land. Five experts voted for a strongly advantageous effect, eleven for a weakly advantageous effect. Just two experts expert saw a negative effect. When focusing only on rural regions, the expert judgement was quite similar.

Figure 3.1: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on agriculture depending on irrigated land



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Figure 3.2: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on agriculture depending on irrigated land in rural regions

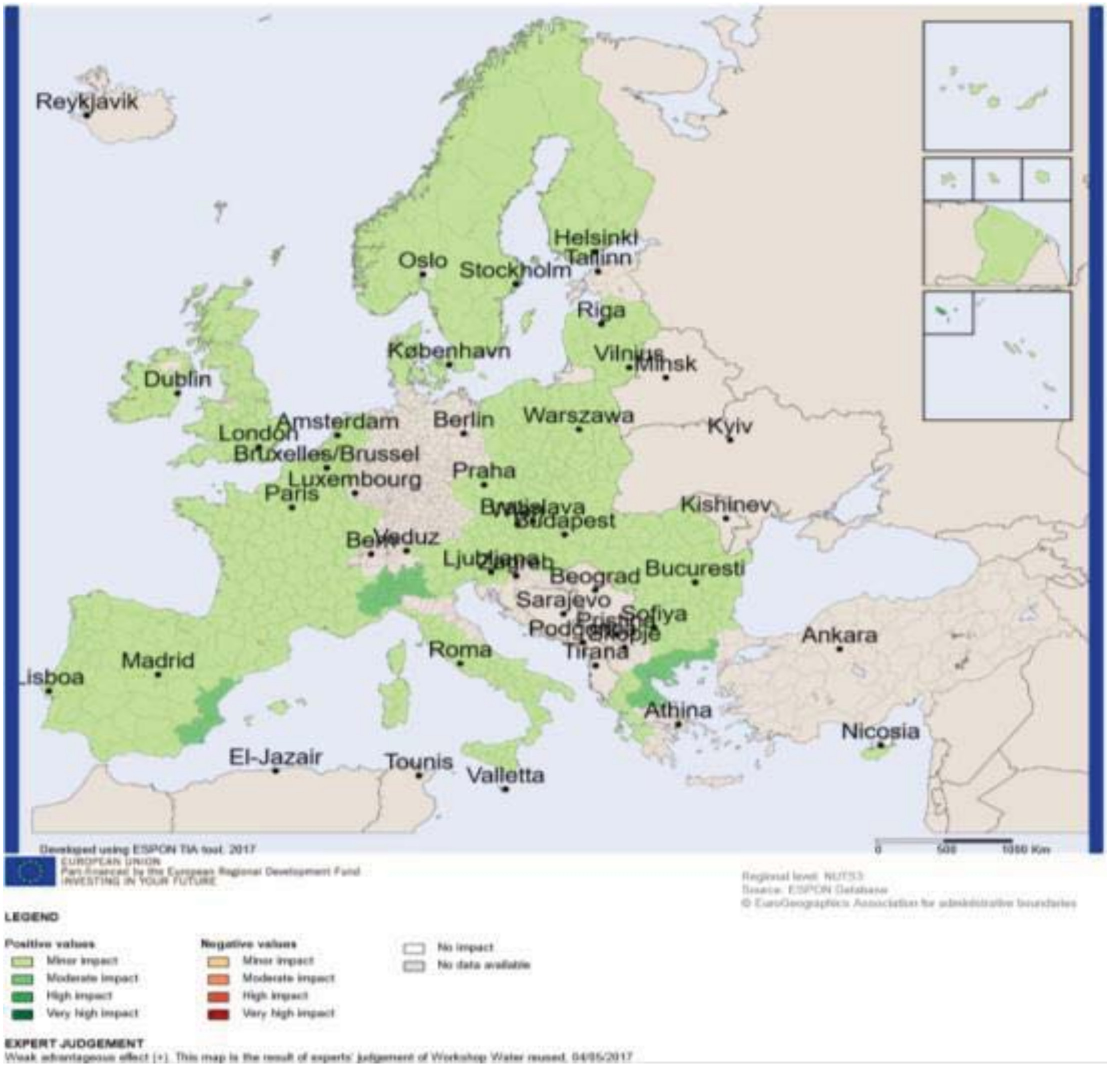


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

The sensitivity of agriculture depending on irrigated land is measured by the indicator "share of irrigated land". It is assumed that a higher share of irrigated land makes a region more sensitive towards policies influencing the conditions of irrigation.

The following map shows the potential territorial impact of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on agriculture depending on irrigated land. It combines the overall expert judgement of a weakly advantageous effect with the given sensitivity of regions. Spanish regions on the Mediterranean coast, Greek regions on the Northern coast of the Aegean Sea and Italian regions around Torino could benefit from a moderate positive effect. All other regions could gain a minor positive impact.

Map 3.1: Result of the expert judgement: Agriculture depending on irrigated land affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect

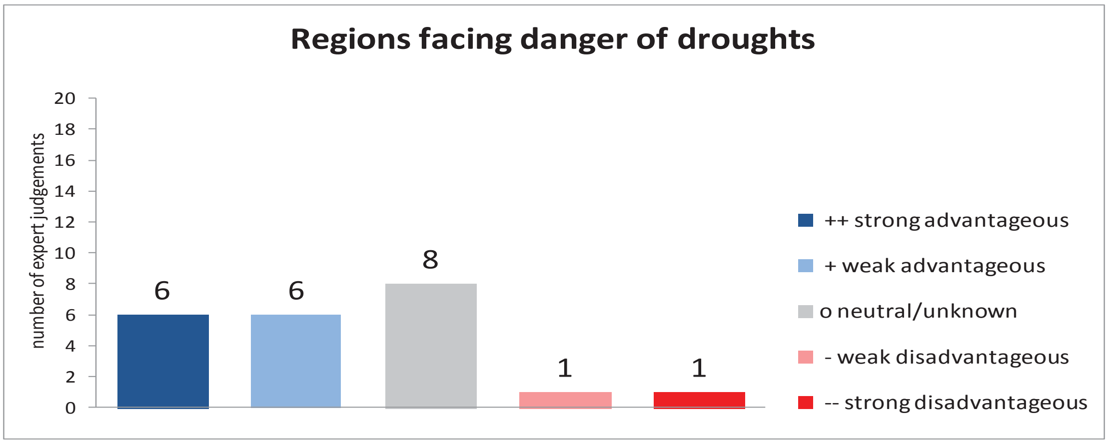


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

3.2 The potential territorial impact on regions facing danger of droughts

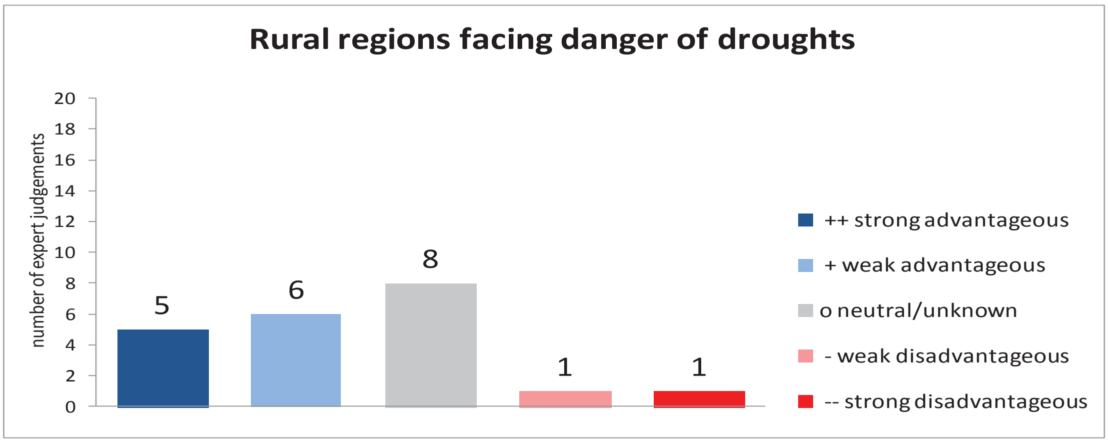
The experts estimated that the implementation of the EU initiative setting minimum quality requirements for reused water in agricultural irrigation and aquifer recharge could contribute to reduce the lack of water in those regions that are suffering from water scarcity. According to the experts it could be a component to mitigate the effects of climate change connected to water scarcity and droughts. A majority of the experts estimated that this would bring weak or even strong advantageous effects on regions facing danger of droughts. However, we should note that a substantial number thought that it will have neutral effects. Only two experts judged the effects as disadvantageous. When focusing only on rural regions, the expert judgement was quite similar.

Figure 3.3: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on regions facing danger of droughts



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Figure 3.4: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on rural regions facing danger of droughts



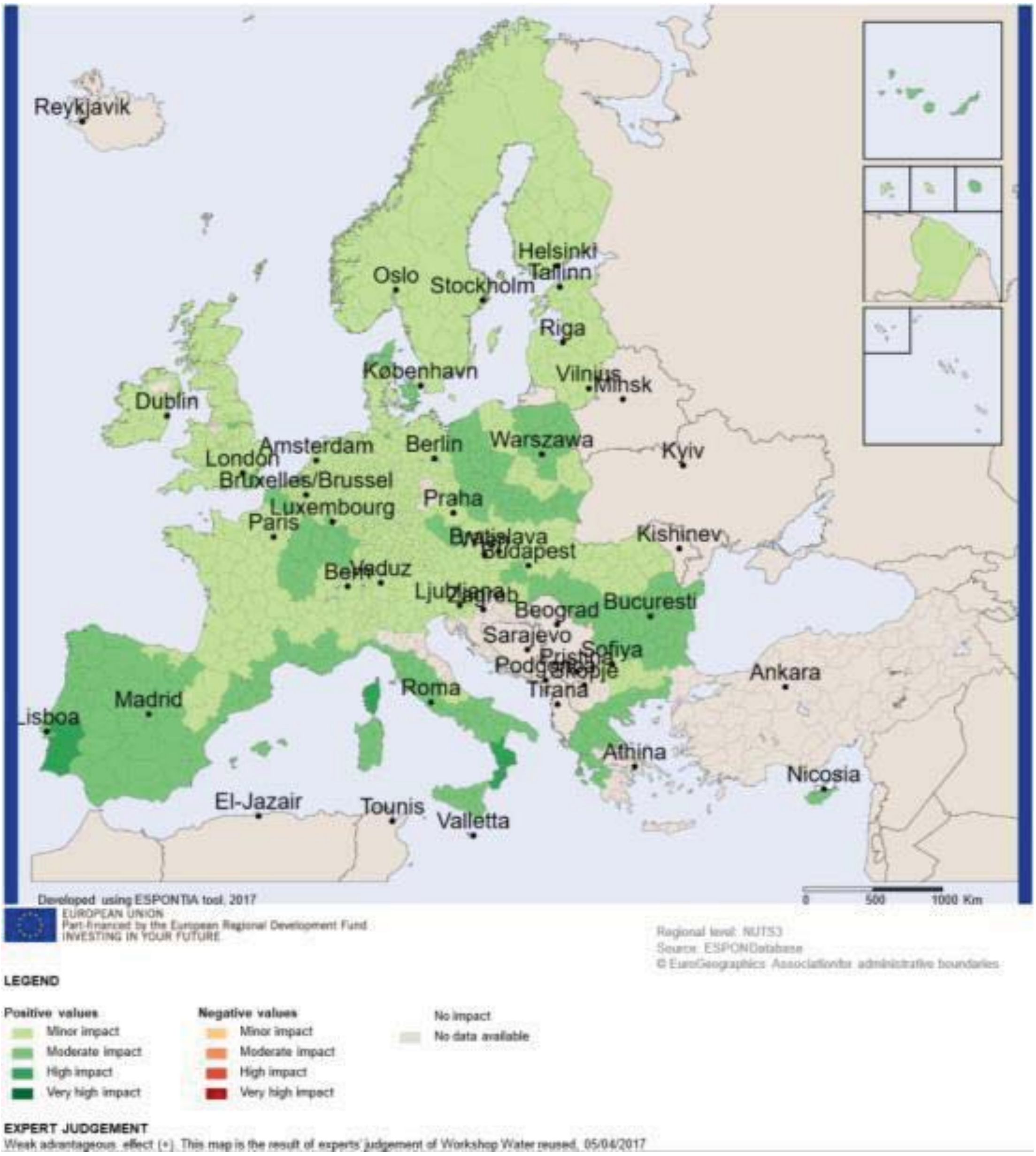
Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

The indicator picturing the sensitivity of a region facing danger of droughts is measured by the probability of forest fires. This indicator was criticized by several experts, because they judged the cause-effect relation between the additional options for irrigation reducing the negative effects of droughts for agriculture and the concrete sensitivity indicator (probability of forest fires) as too weak. Consequently, eight experts did not see any effect of the initiative on this indicator and 3 experts considered that this indicator was not relevant at all.

The following map shows the potential territorial impact on regions facing danger of droughts by combining the expert judgement of the weak advantageous effect with the corresponding sensitivity. Based on that regions which could gain a moderate positive impact are situated in the South of Europe (Portugal, Spain, the Mediterranean coast of France, Italy, Greece, Cyprus) in the East of Europe (East of Poland, South of Hungary, parts of Romania and Bulgaria) and in the centre of France. Some regions in the South of Portugal and the very South of Italy and Haute-Corse could gain even a highly positive impact. For the other regions there would be only a minor impact.

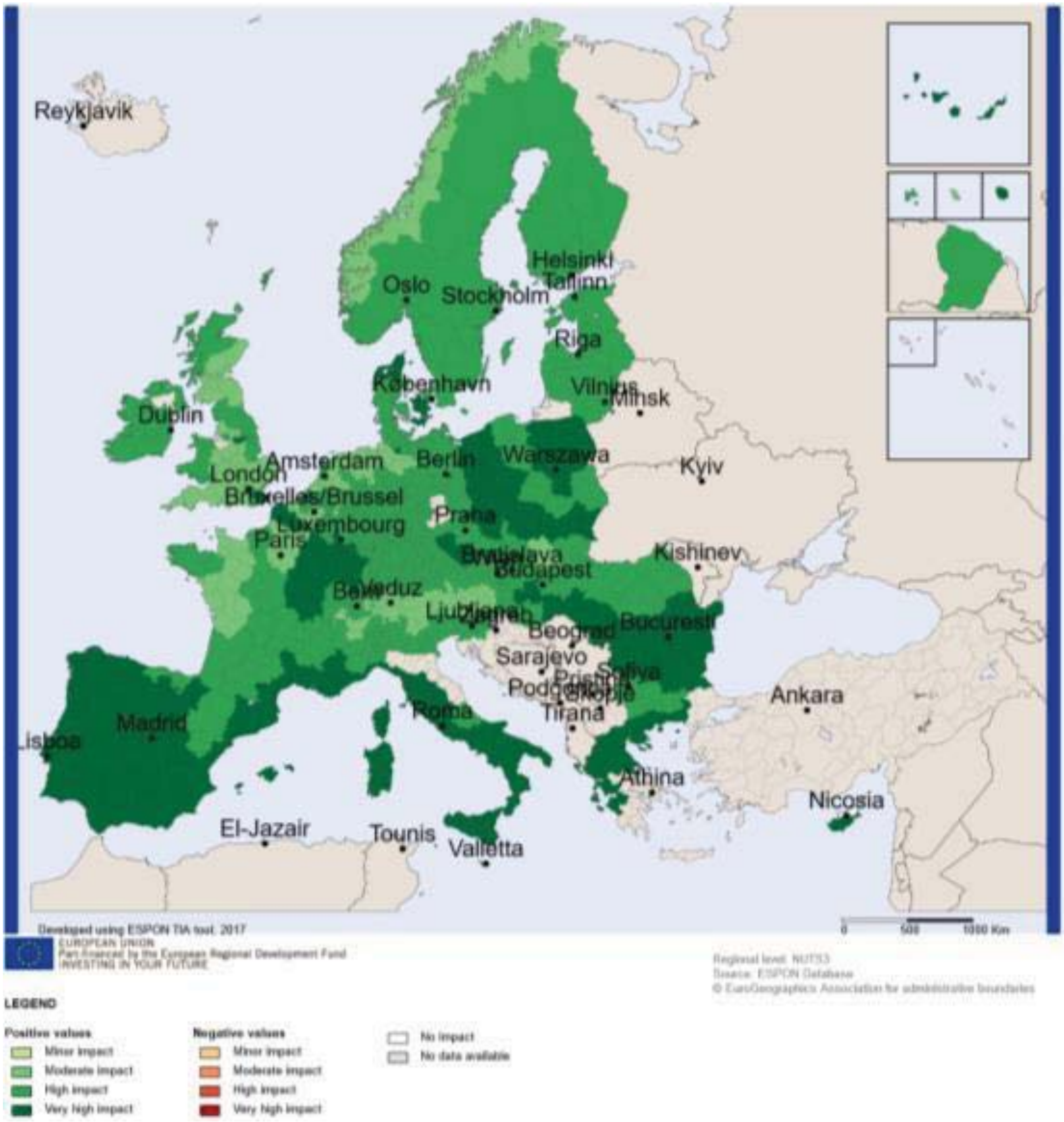
In case of the expert judgement of a strong advantageous effect the impact on the regions would be respectively higher, up to a very high impact for regions in the South and East of Europe.

Map 3.2: Result of the expert judgement: Regions facing danger of droughts affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Map 3.3: Result of the expert judgement: Rural regions facing danger of droughts affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: strong advantageous effect



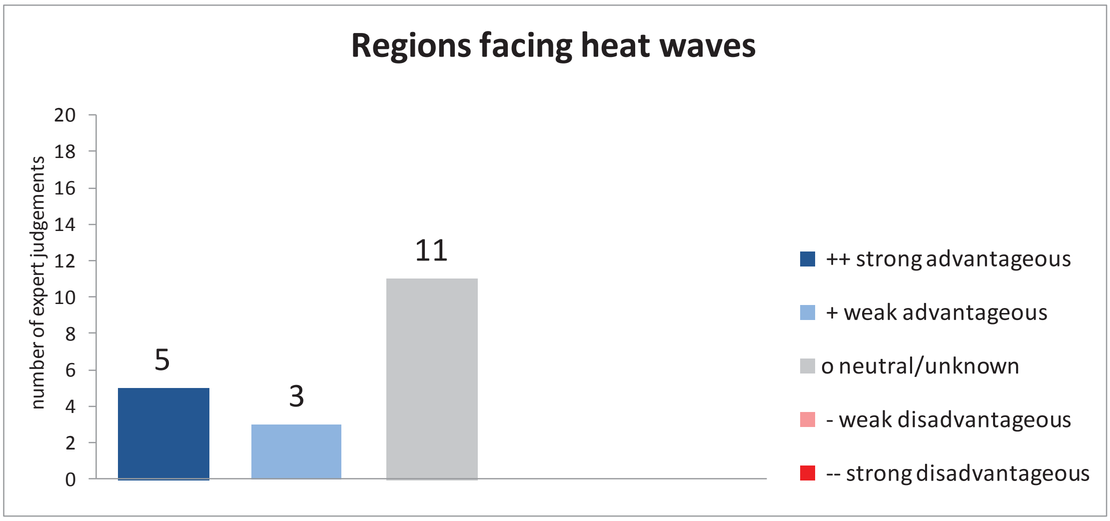
Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

3.3 The potential territorial impact on regions facing heat waves

In the workshop the experts judged that the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge would bring advantageous effects on regions facing heat waves. No one voted for a negative effect.

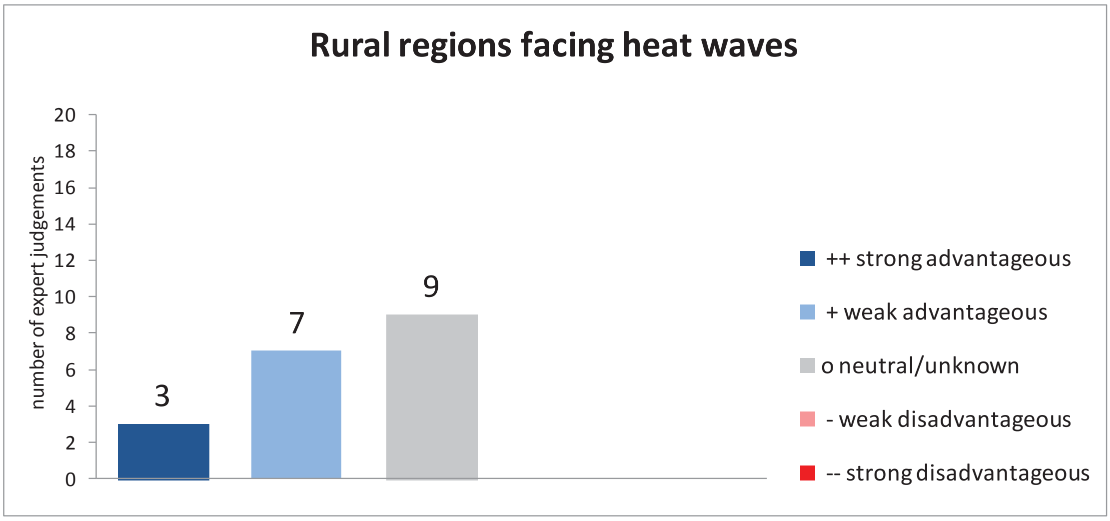
The indicator picturing the sensitivity of a region facing heat waves was measured by the number of days over 30 °C. This indicator was criticized by several experts, because they judged the cause-effect relation between the additional options for irrigation reducing the negative effects of heat waves for agriculture and the concrete sensitivity indicator as too weak. Consequently, a large group of experts did not see any effect of the EU initiative on this indicator. Due to this judgement, it was decided as not useful to picture this voting in maps.

Figure 3.5: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on regions facing heat waves



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Figure 3.6: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on rural regions facing heat waves

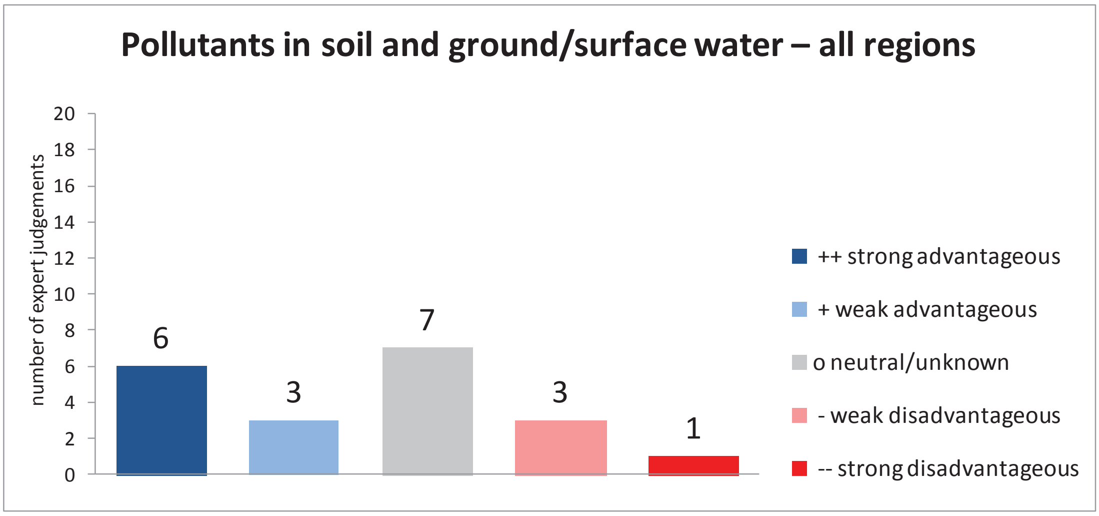


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

3.4 The potential territorial impact based on pollutants in soil and ground/surface water indicator

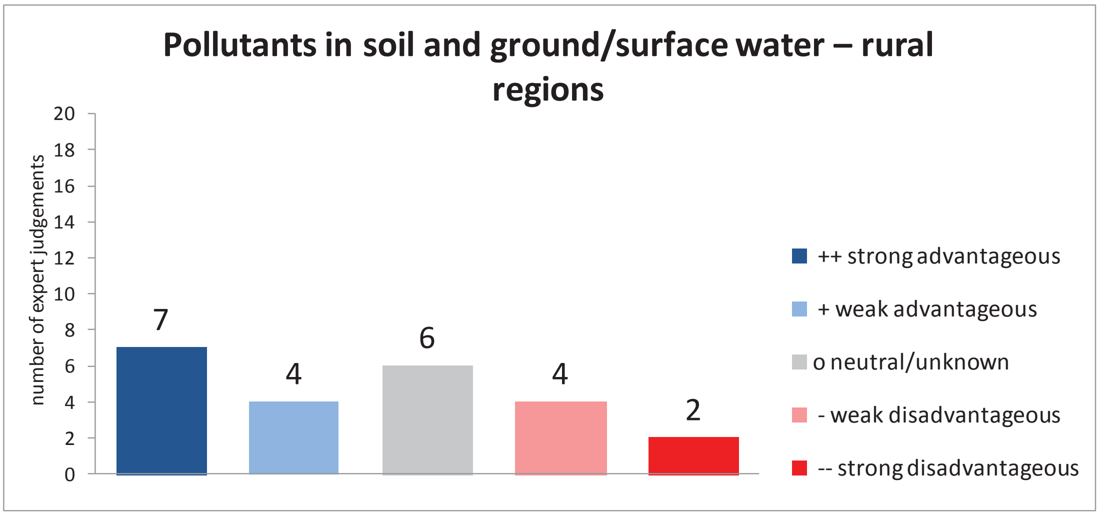
The experts' opinion on the potential effects of the EU initiative based on the indicator pollutants in soil and ground/surface water was quite diverging. A majority of them judged the effects as strongly advantageous (6 for all regions, 7 for rural regions) or weakly advantageous (3 for all regions, 4 for rural regions). However, a minority judged the effects weakly or even strongly disadvantageous. About one third of the experts judged the effects as neutral or unknown. Consequently, no clear effect of the EU initiative on pollutants in soil and ground/surface water can be given.

Figure 3.7: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements on pollutants in soil and ground/surface water



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Figure 3.8: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements on pollutants in soil and ground/surface water in rural regions



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

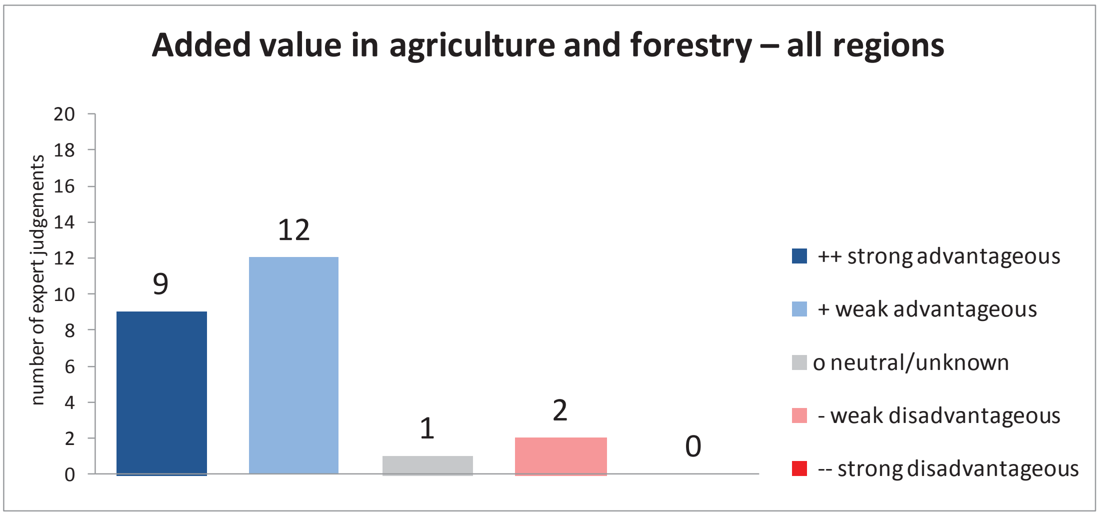
The sensitivity of a region towards policies affecting the pollution of soil and ground and surface water is measured by a proxy indicator taking into account the population density and the employment density. As this indicator is more responding to pollutants caused by urban developments than by agricultural land use, a map could lead to wrong interpretations. Taking into account the weak validity of the indicator measuring effects caused by agriculture and the quite inhomogeneous expert judgement, no further analysis and mapping seems to be useful.

4 Results of the TIA quick check: Potential territorial impact considering the economy aspects

4.1 The potential territorial impact based on the added value in agriculture and forestry

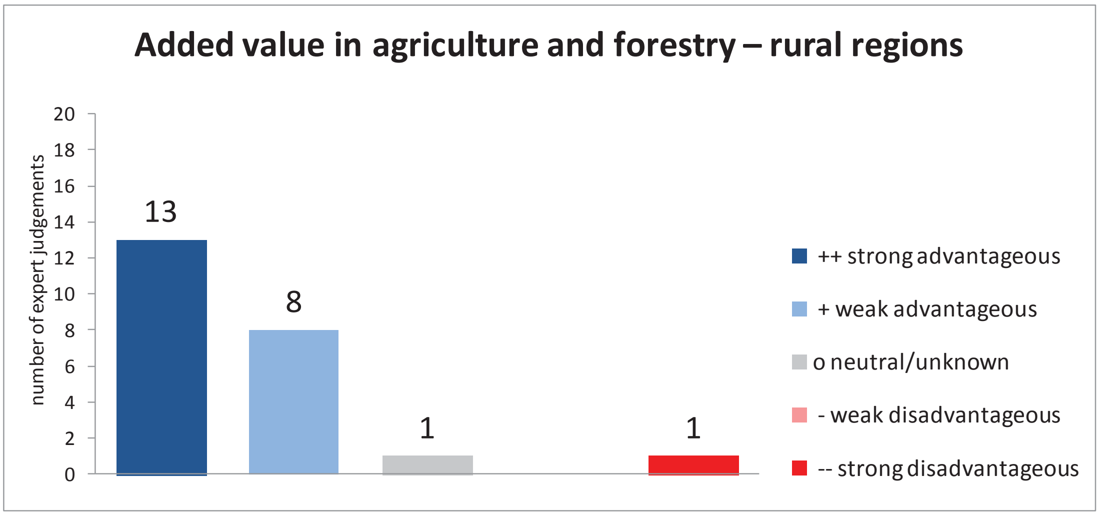
There was a clear agreement of the experts that the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge would definitely have a positive effect on the on the added value in agriculture and forestry. When looking at all regions, nine experts judged the effects as strongly advantageous, twelve judged them as weakly advantageous and only two as weakly disadvantageous.

Figure 4.1: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on added value in agriculture and forestry



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Figure 4.2: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on added value in agriculture and forestry in rural regions



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

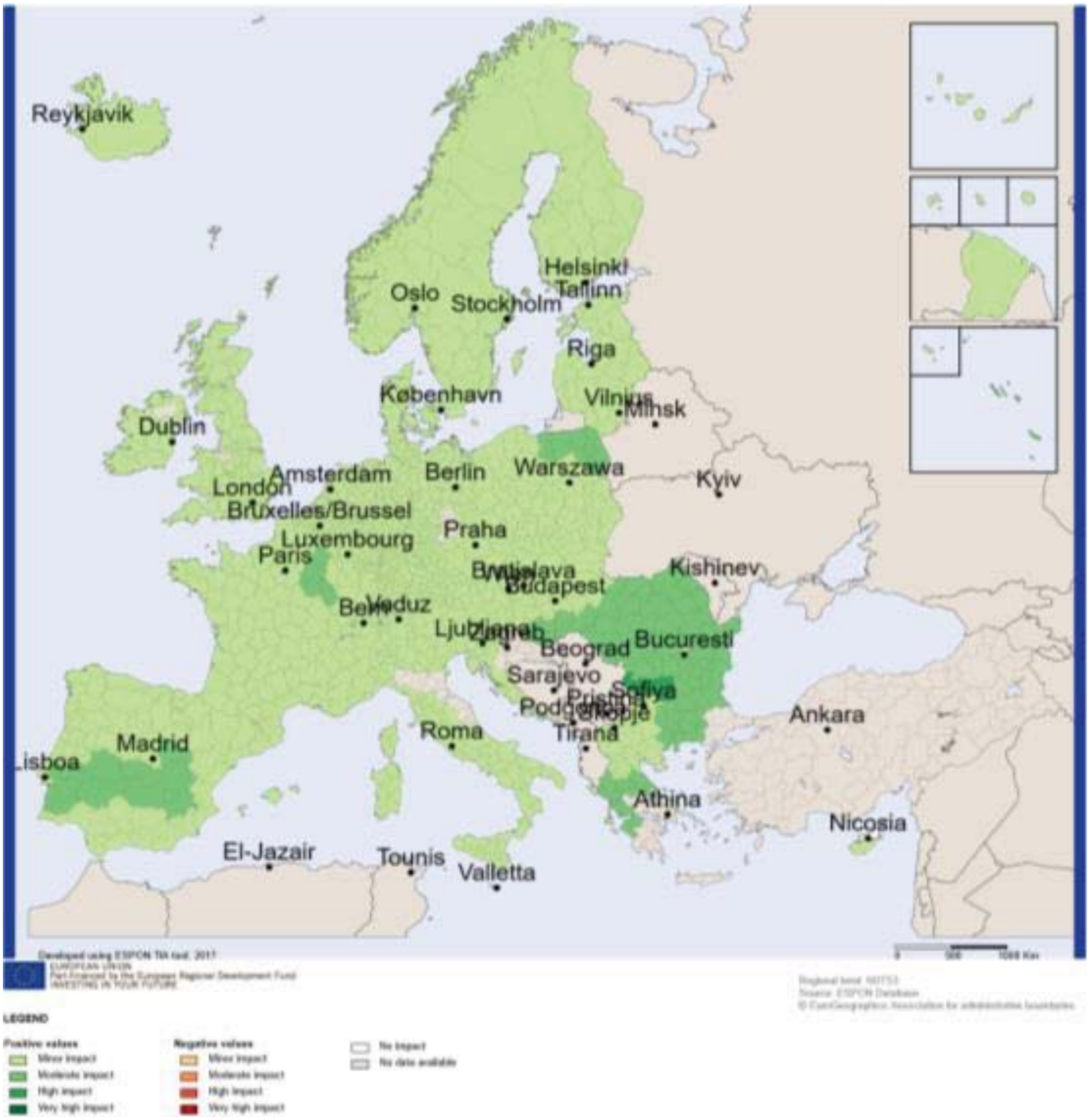
When focusing **on rural regions**, a majority of 13 experts judged the effects of this initiative as strongly advantageous, eight judged them as weakly advantageous and one judged them as strongly disadvantageous.

The sensitivity of regions is measured by the indicator "gross value added in agriculture and forestry". Regions where agriculture and forestry have an important share of the total regional gross value added are expected to benefit more from the EU initiative stimulating the added value of agriculture and forestry than others. The following maps show the potential territorial impact of setting minimum quality requirements for reused water in agricultural irrigation and aquifer recharge by combining the expert judgement with the given sensitivity.

Taking into account the potential effects on all regions, the majority of the experts presumes a weakly advantageous effect. This would lead to **minor positive impacts on most regions**. When they can use the new options for reusing sewage water, regions with a high economic importance of agriculture could gain a moderate positive impact as e.g. in Romania, Bulgaria, the North of Greece, the North East of Poland, the centre of Spain and the South of Portugal.

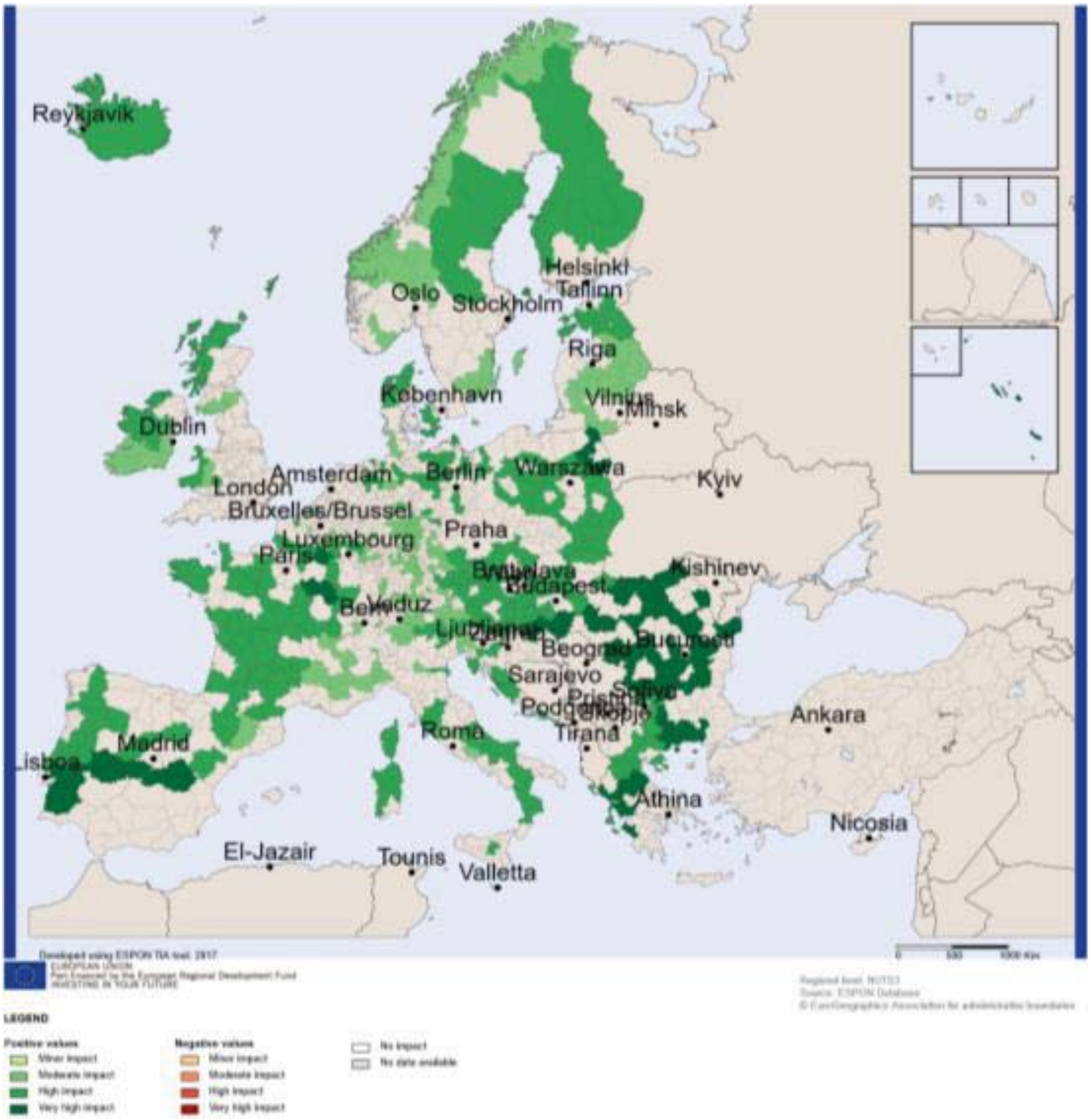
For rural regions the majority of the experts presumes a strongly advantageous effect. When they can use the new options for reusing sewage water rural regions with a high economic importance of agriculture rural regions could gain a very high positive impact as e.g. in Romania, Bulgaria, the North of Greece, the North East of Poland, South of Madrid and in the South of Portugal.

Map 4.1: Result of the expert judgement: Added value in agriculture and forestry affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Map 4.2: Result of the expert judgement: Added value in agriculture and forestry in rural regions affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: strong advantageous effect



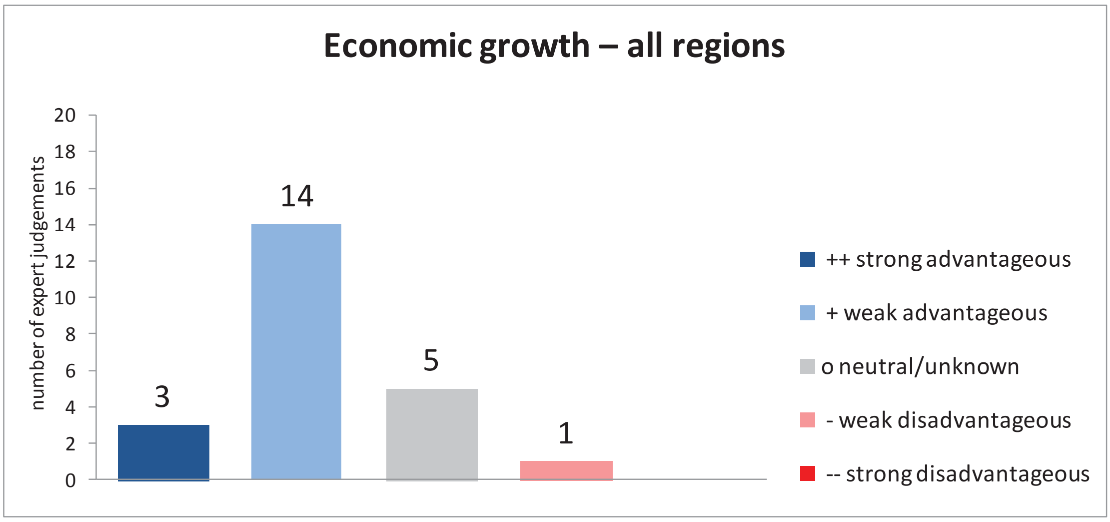
Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

4.2 The potential territorial impact based on the economic growth

The experts identified a positive effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on the overall economic growth of all regions. Three voted for a strongly advantageous effect, fourteen for a weakly advantageous effect. Just one expert saw a weakly disadvantageous effect.

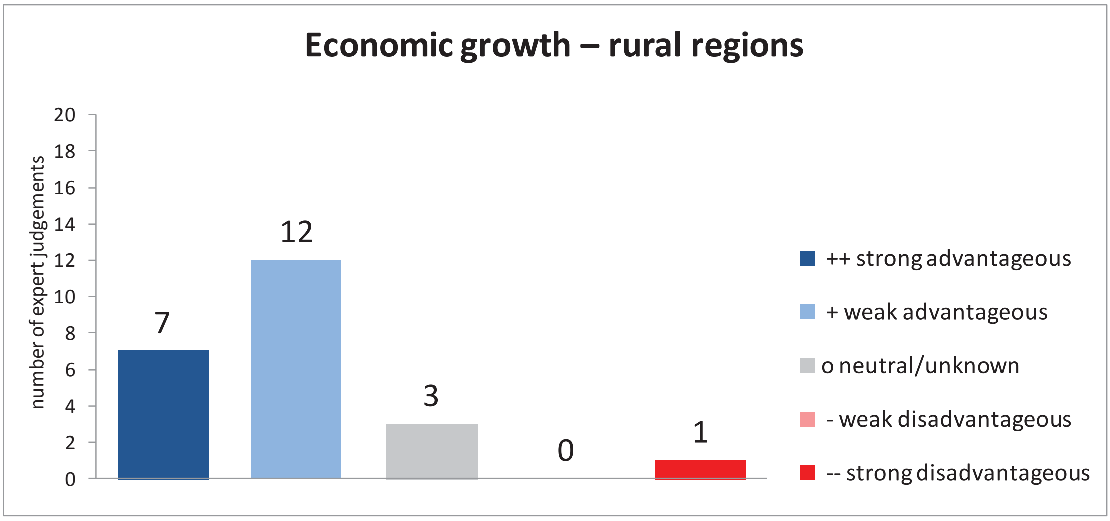
When focusing on rural regions the judgement was even more positive: In this case seven voted for a strongly advantageous effect and twelve for a weakly advantageous effect.

Figure 4.3: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on economic growth



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Figure 4.4: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on economic growth in rural regions

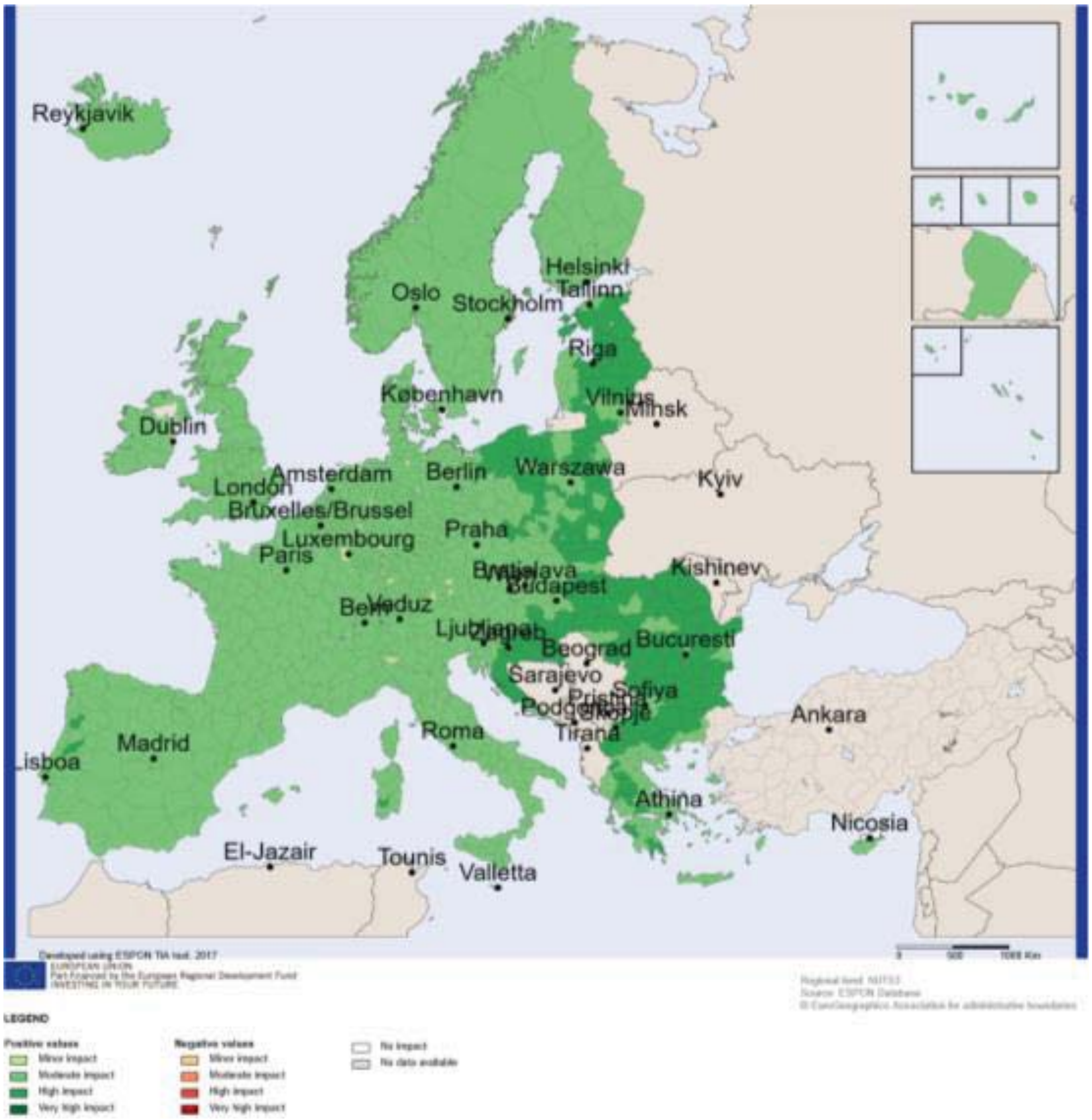


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

The sensitivity of the regions is measured by the indicator "GDP per capita". Regions with lower GDP per capita are expected to benefit more from the EU initiative (like the one on reuse of water) aimed at GDP growth increase and that inadvertently harm economic growth. The following map shows the potential territorial impact of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on the economy growth by combining the judgement of the majority of the experts (weakly advantageous effect) with the corresponding sensitivity.

It is assumed that <u>especially the Eastern European regions in the Baltic Sea and the Black Sea and some regions in Greece could potentially benefit with a high positive impact from the EU initiative. Most other regions would have a moderate impact.</u>

Map 4.3: Result of the expert judgement: Economic growth affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect

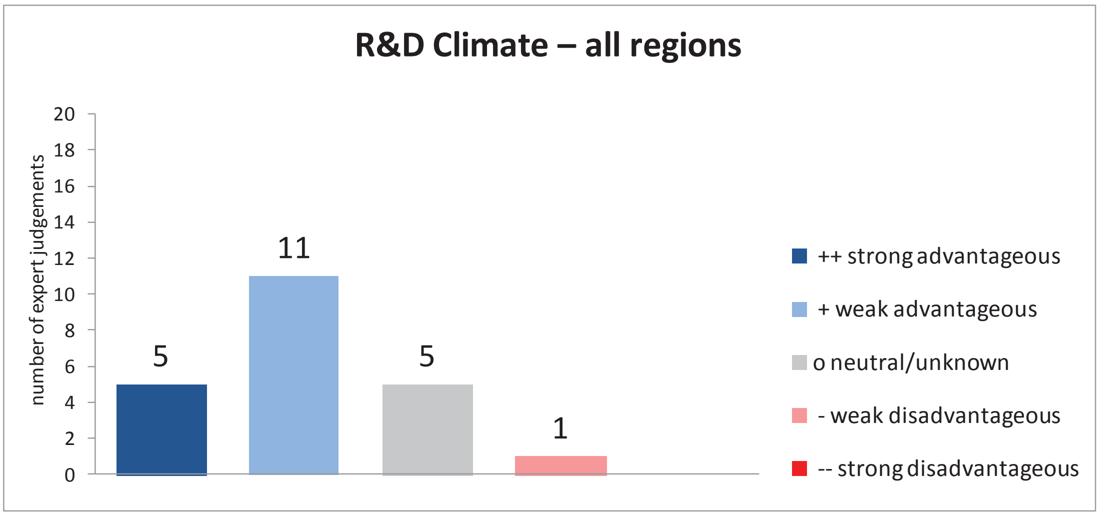


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

4.3 The potential territorial impact based on the R&D Climate

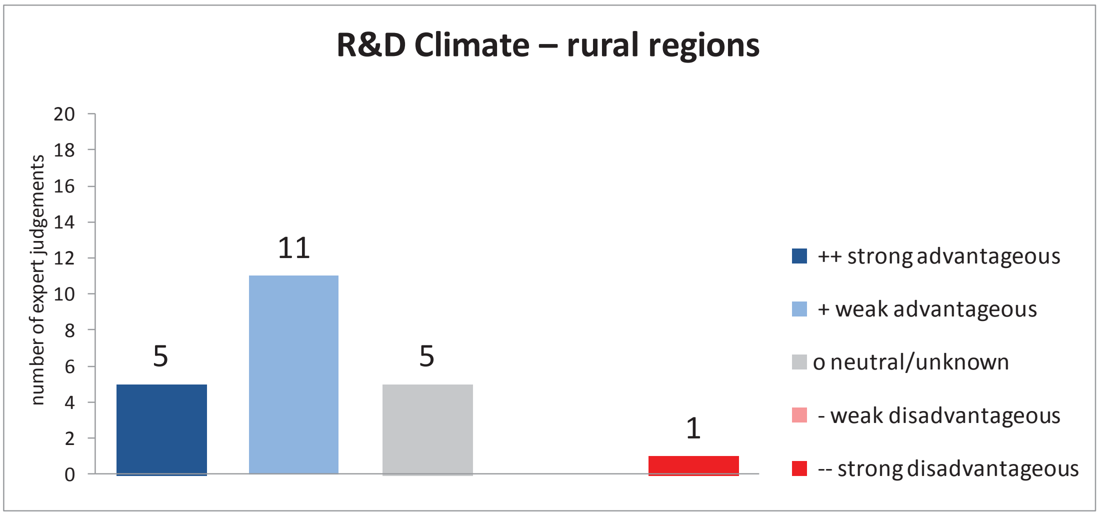
The experts assumed that new possibilities for using new technologies could arise in connection with the reuse of water in agricultural irrigation and aquifer recharge, which could stimulate the development of technologies in this field. Consequently, the experts saw an advantageous effect of the EU initiative on the R&D climate: Five voted for a strongly advantageous effect, eleven for a weakly advantageous effect. This result was the same for all regions as well as for rural regions.

Figure 4.5: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on R&D Climate (R&D expenditure)



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Figure 4.6: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on R&D Climate (R&D expenditure) in rural regions



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

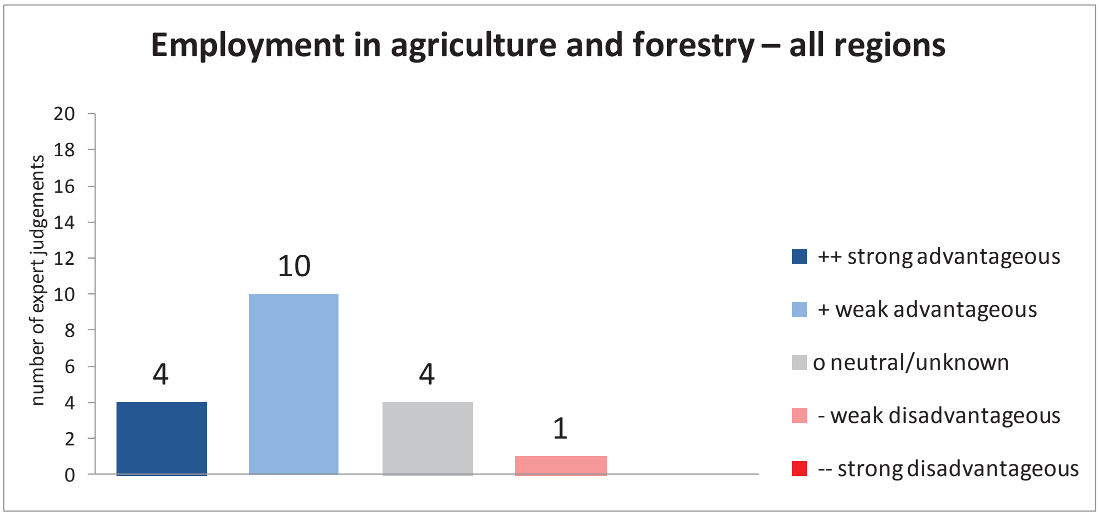
The sensitivity of regions related to the R&D climate is measured by the indicator “R&D expenditure”. Regions with an already highly innovative climate and with a greater share of enterprises engaged in product and/or process innovation activities are considered to be more sensitive to EU initiatives influencing innovation than others. Combining the expert judgement of the weakly advantageous effect with the corresponding sensitivity results in a quite equal distribution of a minor positive impact in most European regions.

5 RESULTS OF THE TIA QUICK CHECK: POTENTIAL TERRITORIAL IMPACT BASED ON SOCIETY ASPECTS

5.1 The potential territorial impact based on the employment in agriculture and forestry

The development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge **could improve the public acceptance of reused water, which could open chances for development, especially in rural areas.** Consequently, the participants judged the effects on the employment in agriculture and forestry as positive. When looking at all regions[13], four experts judged the effects as strongly advantageous and ten as weakly advantageous.

Figure 5.1: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on employment in agriculture and forestry

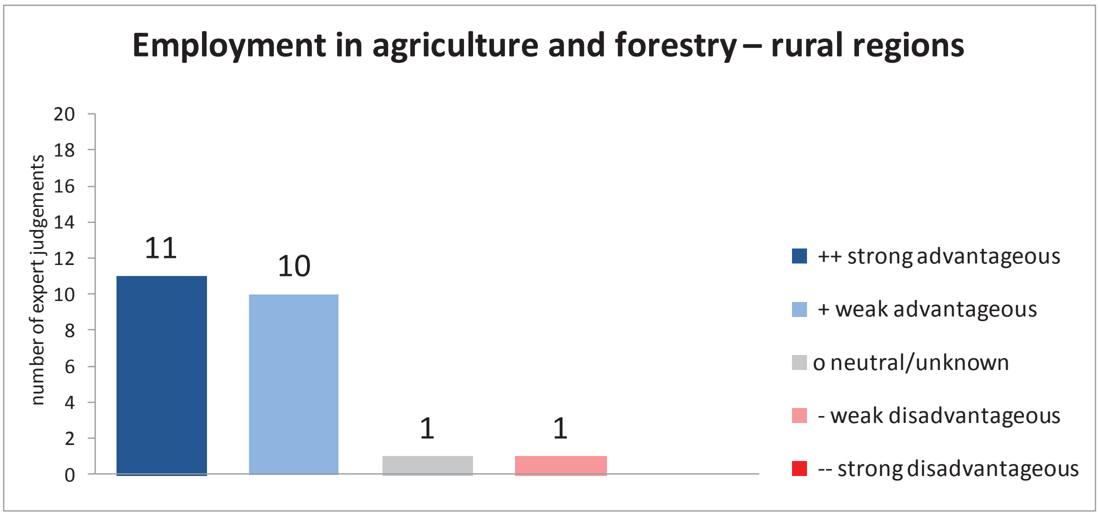


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

When focusing the judgement on rural regions a majority of eleven experts judged the effects of this initiative as strongly advantageous and additionally ten experts judged them as weakly advantageous.

Figure 5.2: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on employment in agriculture and forestry in rural regions

[13] 5 out of the 24 experts thought that this indicator is not relevant when considering all regions and therefore chose not to vote for it.

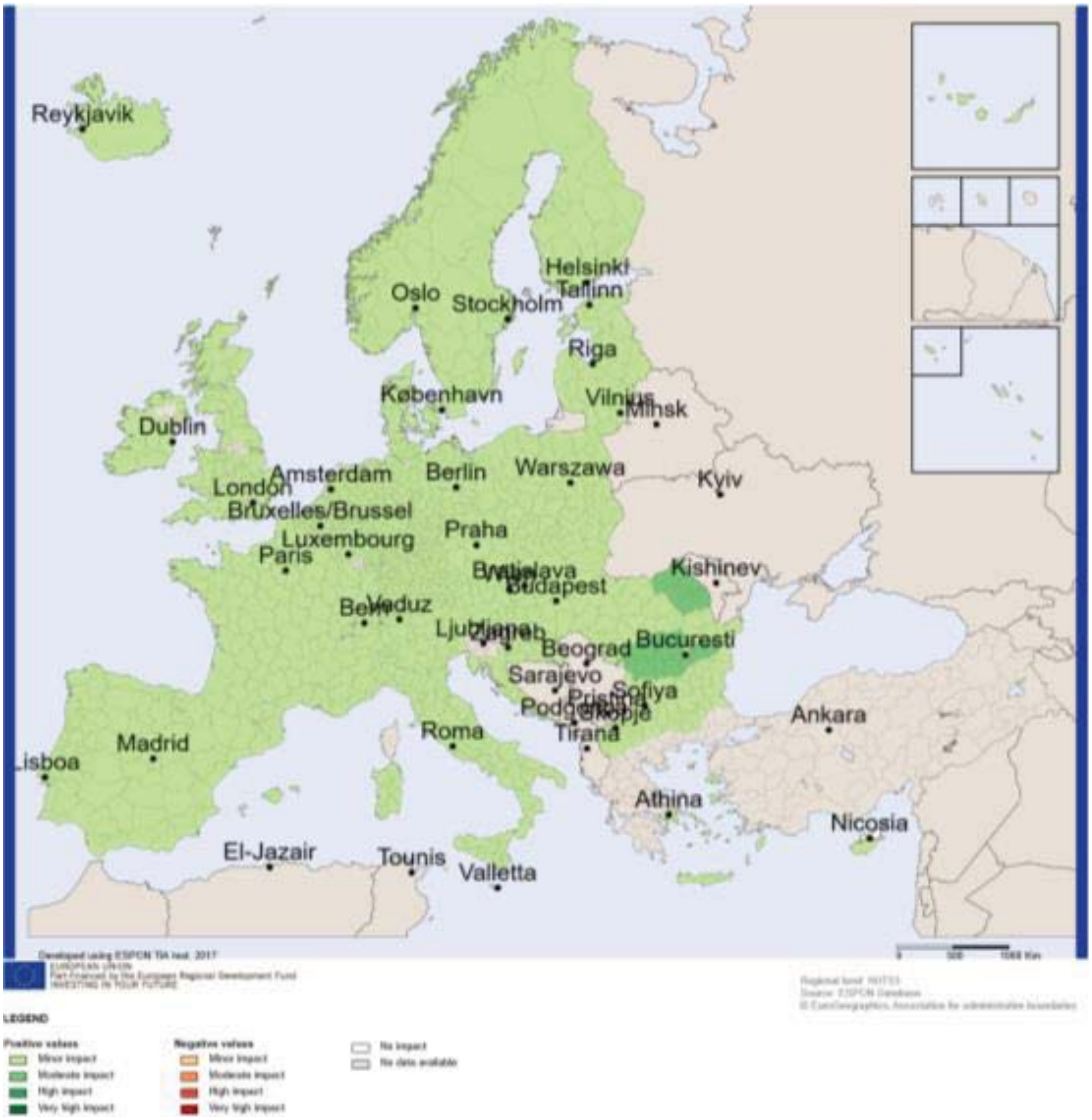


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

The sensitivity of the regions related to agriculture and forestry is measured by the indicator "share of employment" in these sectors. Regions with a greater share of employment in agriculture and forestry are likely to be more affected from changes in the level of employment in this sector induced by the Commission initiative.

The following maps show the potential territorial impact of setting minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on the employment in agriculture and forestry by combining the expert judgement with the sensitivity.

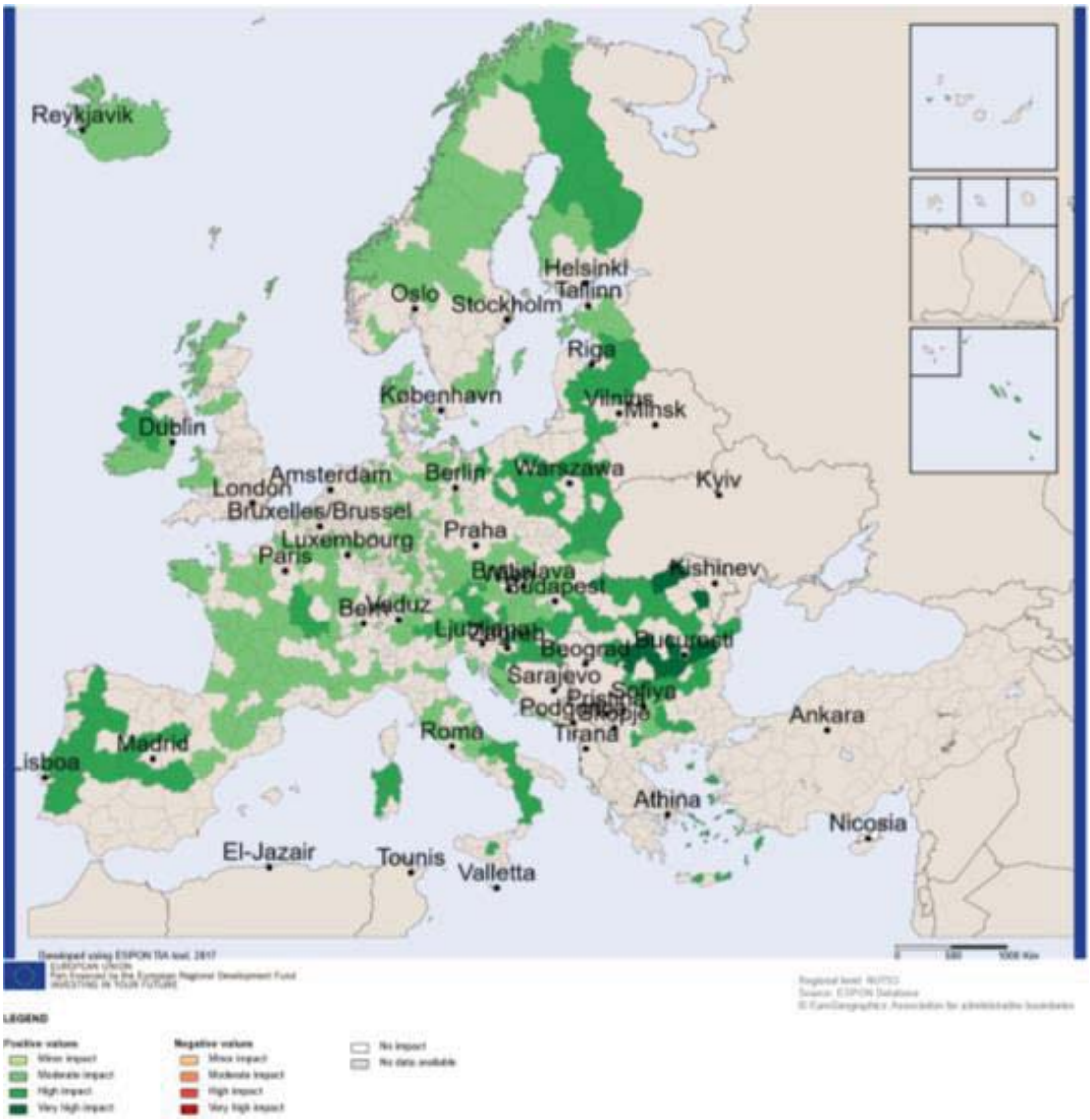
Map 5.1: Result of the expert judgement: Employment in agriculture and forestry affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Taking into account the effects on all regions the majority of the experts presumes a <u>weakly advantageous effect.</u> This would lead to minor positive impacts on most regions. <u>Regions in the North and the South of Romania could gain a moderate positive impact if they can use the new options for reusing waste water</u>

Map 5.2: Result of the expert judgement: Employment in agriculture and forestry in rural regions affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: strong advantageous effect



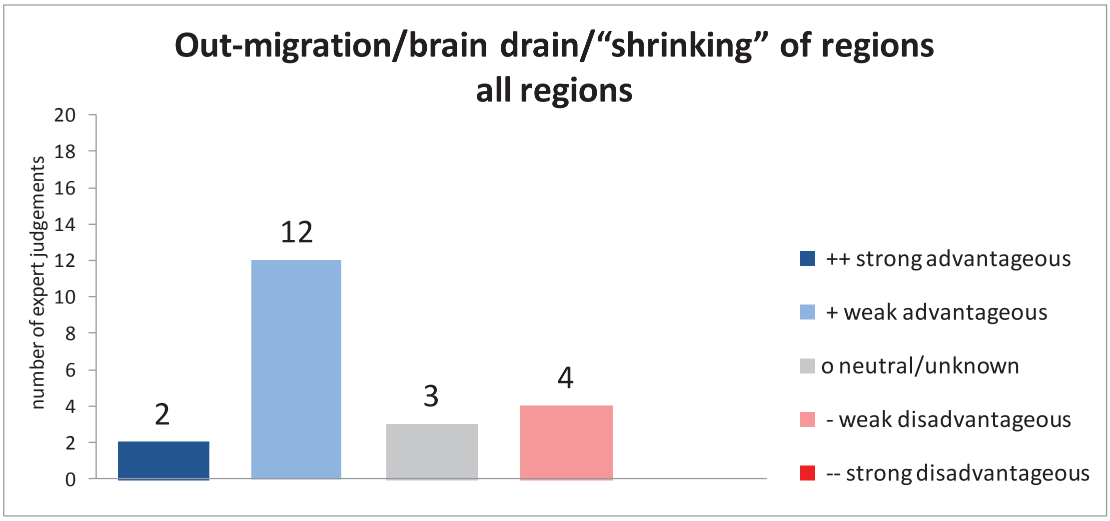
Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Focusing on rural regions the majority of the experts voted for a strongly advantageous effect. If they can use the new options for reusing waste water regions as enabled by the proposal of DG ENV to improve agricultural land use, several regions could potentially gain a high or very high positive impact, as e.g. in Lithuania, Finland, Poland, Romania, the South of Italy, Portugal and Spain.

5.2 The potential territorial impact based on out-migration/brain drain/“shrinking” of regions

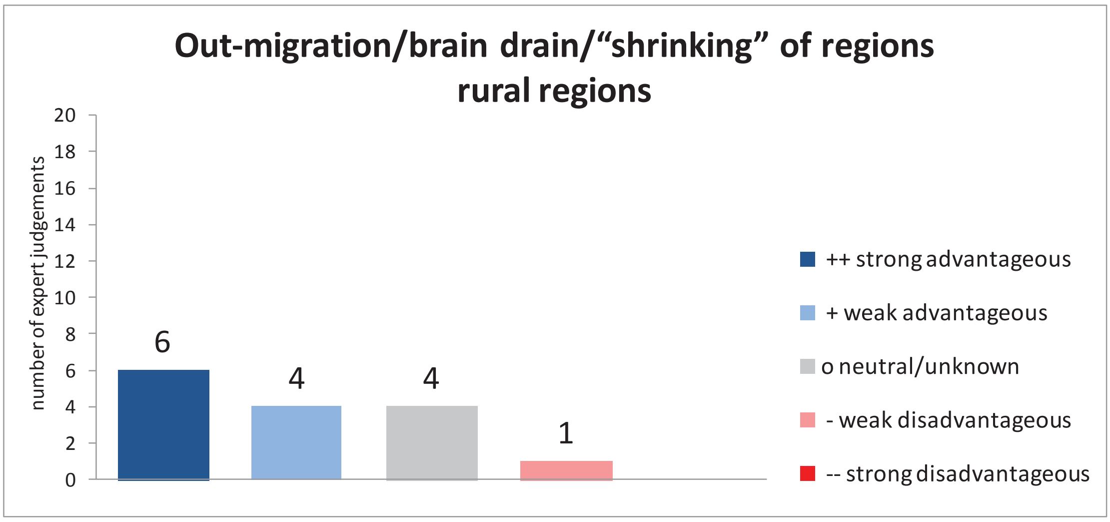
According to the experts’ opinion the improved possibilities for agriculture and related employment possibilities in agriculture could reduce out-migration in currently shrinking regions. Twelve experts voted for a weakly advantageous effect in all regions and two experts voted even for a strongly advantageous effect. Focusing on rural regions[14] the effect was seen even more positively: Six experts voted for a strongly advantageous effect, four experts for a weakly advantageous effect. However, a few participants saw a weakly disadvantageous effect on out-migration.

Figure 5.3: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on out-migration/brain drain/"shrinking" of regions



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Figure 5.4: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on out-migration/brain drain/"shrinking" of rural regions

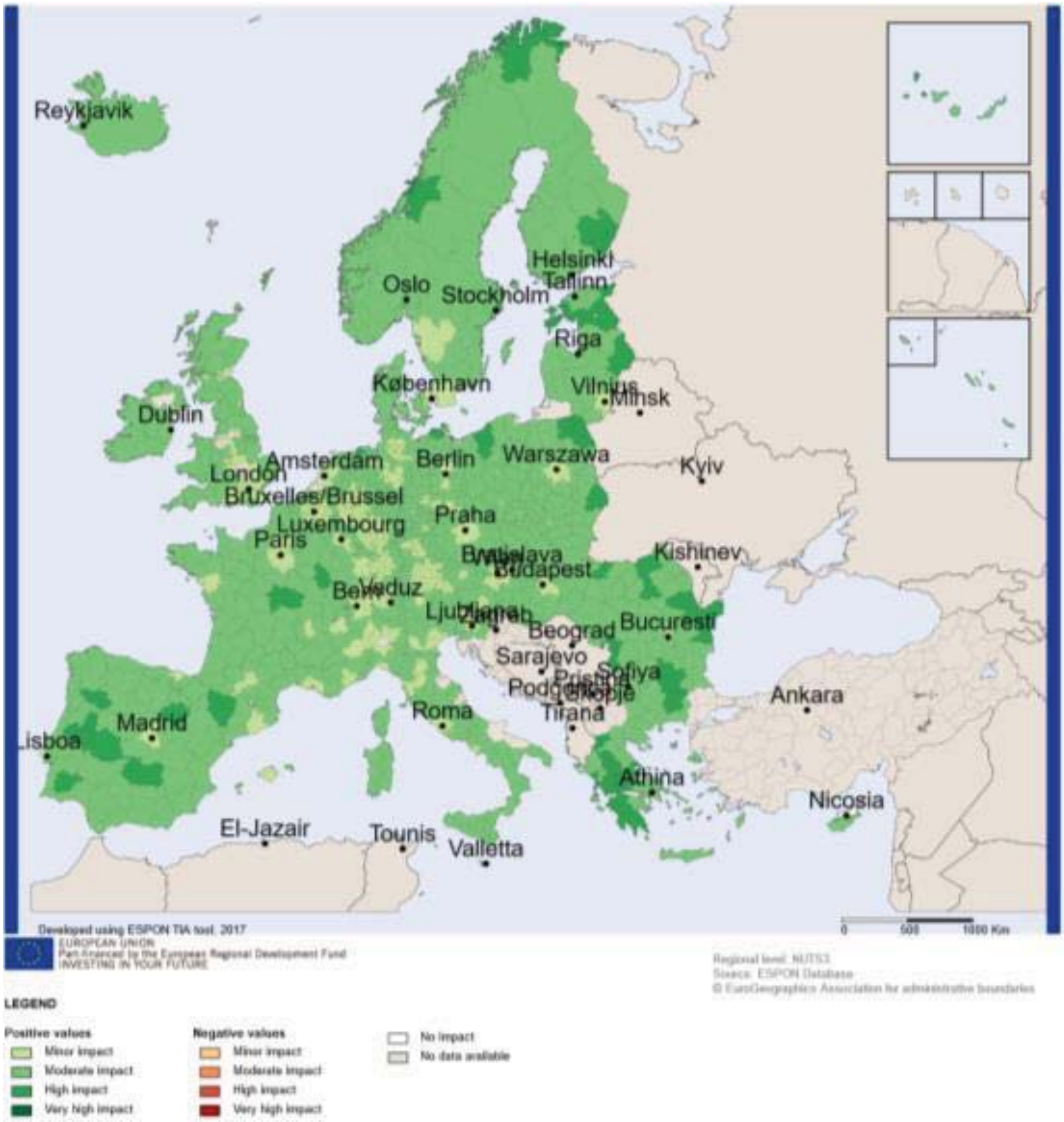


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

[14] The effect of outmigration to rural regions should be taken with cautiousness since 9 out of the 24 experts did not consider this indicator as relevant and therefore chose not to vote

The sensitivity of the regions related to out migration is measured by the indicator "net migration balance" (i.e. immigration minus out-migration on total population). The underlying hypothesis for describing the sensitivity of the regions towards out migration is that regions experiencing out-migration and brain drain will benefit more from actions aimed at their reduction or suffer more from their exacerbation. The following map shows the potential territorial impact of the proposal of DG ENV taking under consideration out-migration and brain drain by combining the expert judgement of the weakly advantageous effect with the corresponding sensitivity. If the regions can benefit from the new possibilities to reuse waste water in agricultural irrigation and aquifer recharge most of them could get a moderately positive impact reducing out migration. Some regions mainly located at the European external borders could gain even a highly positive impact.

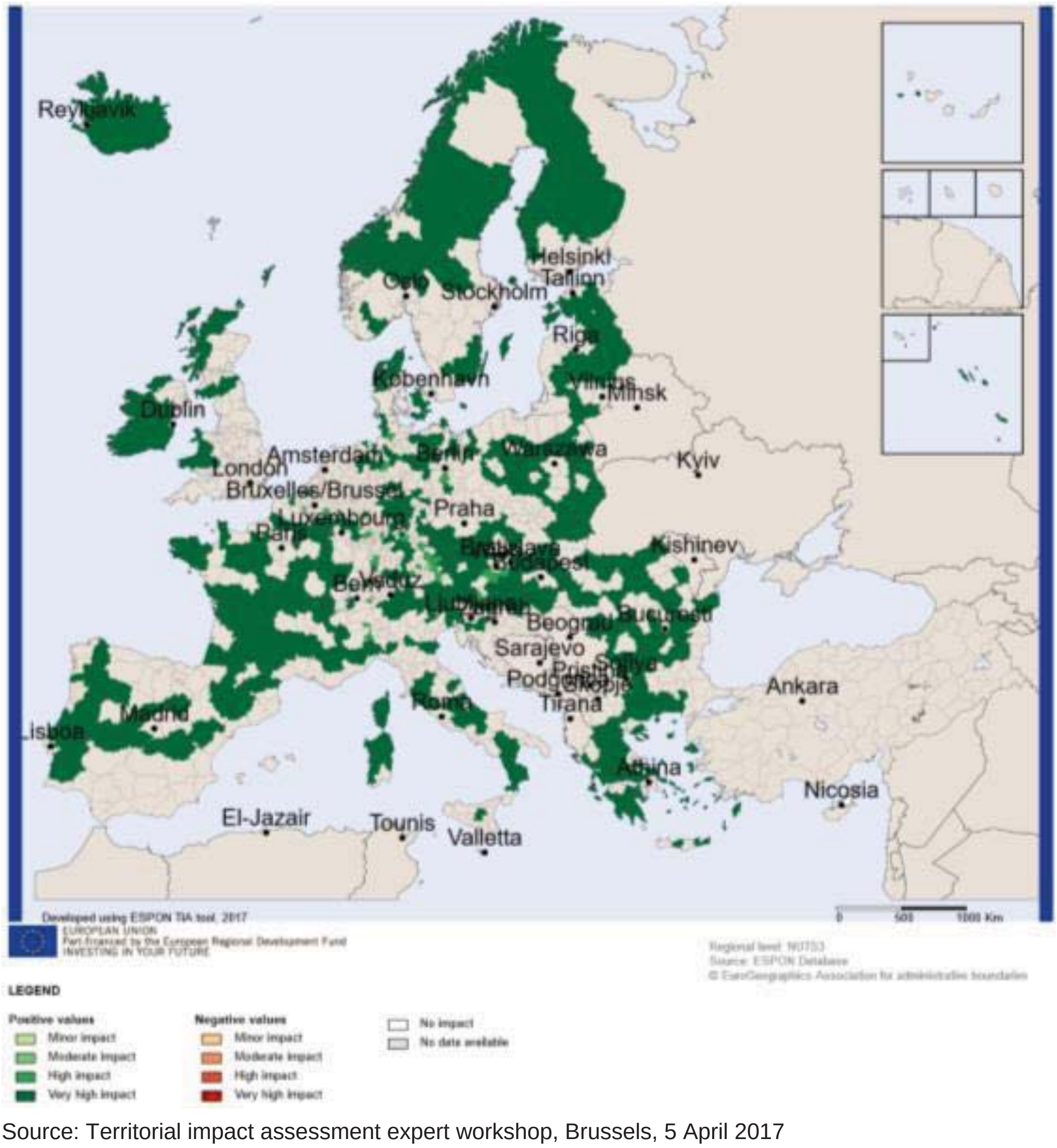
Map 5.3: Result of the expert judgement: Out-migration/brain drain/"shrinking" of regions affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Based on the fact that 9 out of the 24 experts did not consider this indicator relevant (and therefore did not vote for it) and the fact that 4 voted for a neutral effect we consider that the strongly advantageous effect registered by those that actually vote should be taken very cautiously. Assuming that this initiative could lead to a very highly positive impact in rural regions using wastewater in agricultural irrigation and aquifer recharge (See the following map) has limitations.

Map 5.4: Result of the expert judgement: Out-migration/brain drain/"shrinking" of rural regions affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: strong advantageous effect

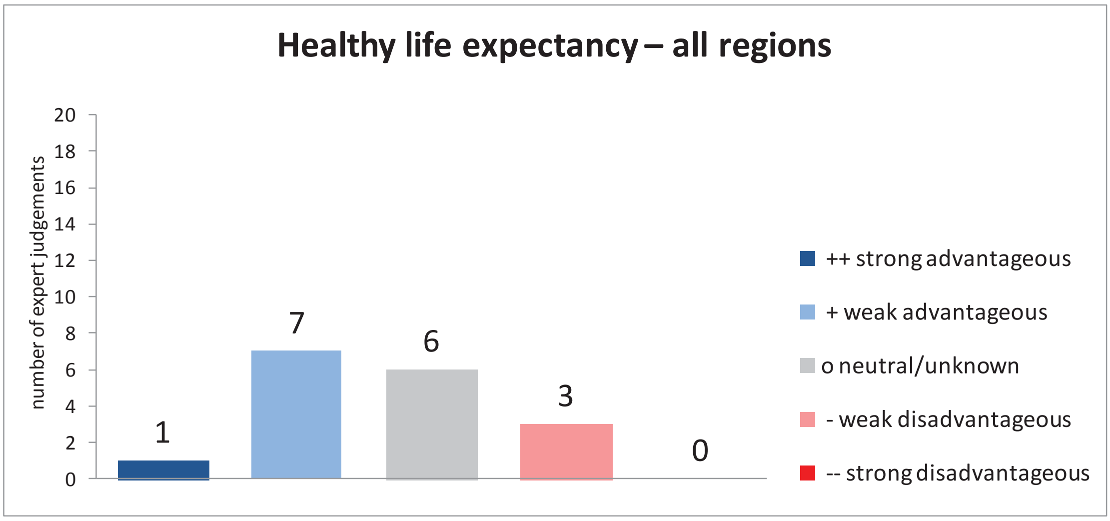


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

5.3 The potential territorial impact based on healthy life expectancy

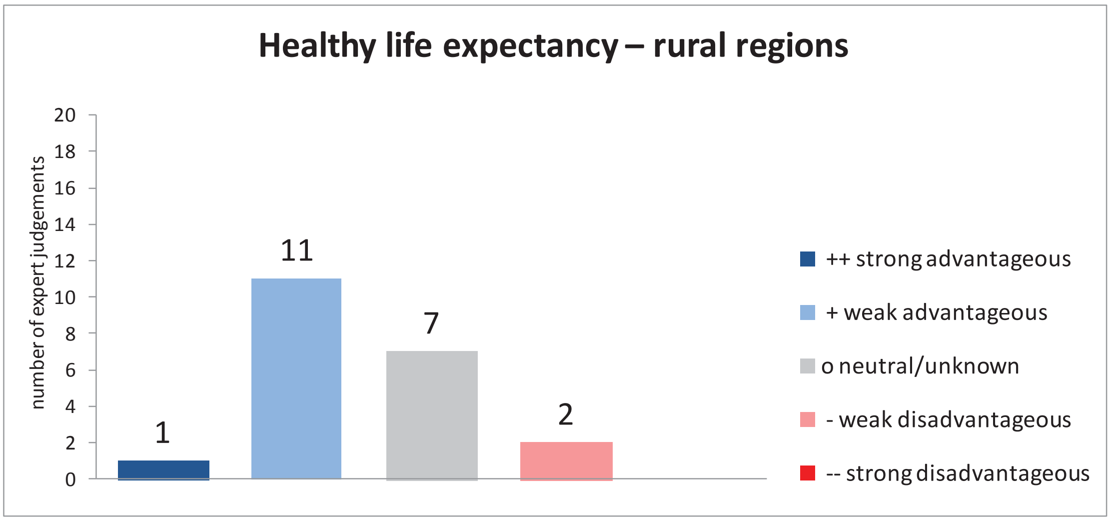
The majority of the participants saw a weak advantageous effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on the health of the population measured by the healthy life expectancy indicator. However, a minority was afraid that this new proposal for DG ENV could lead to a weakly disadvantageous effect on health.

Figure 5.5: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on healthy life expectancy



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Figure 5.6: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on healthy life expectancy in rural regions



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

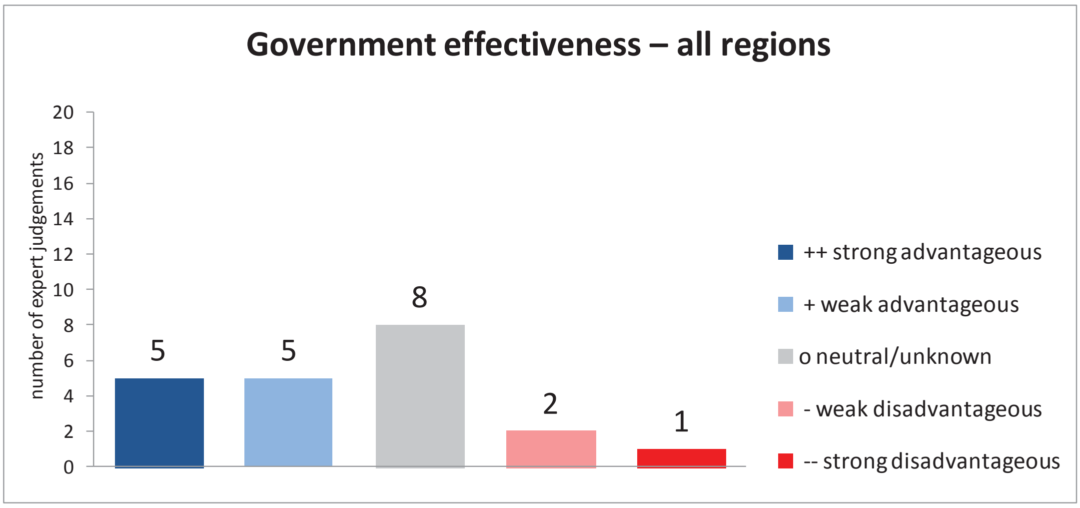
Regions in which the life expectancy is lower are expected to benefit more from policy measures effecting its increase and more negatively influenced by those which decrease it. This indicator was not considered as suitable by several experts, because they judged the cause-effect relation between the additional options for irrigation having positive effects on life expectancy as too weak. Consequently, a large group of experts did not see any effect of setting minimum quality requirements for reused water in agricultural irrigation and aquifer recharge based on this indicator. Due to this judgement, it was decided not useful to picture this voting in maps.

6 Results of the TIA quick check: Potential territorial impact based on governance aspects

6.1 The potential territorial impact on government effectiveness

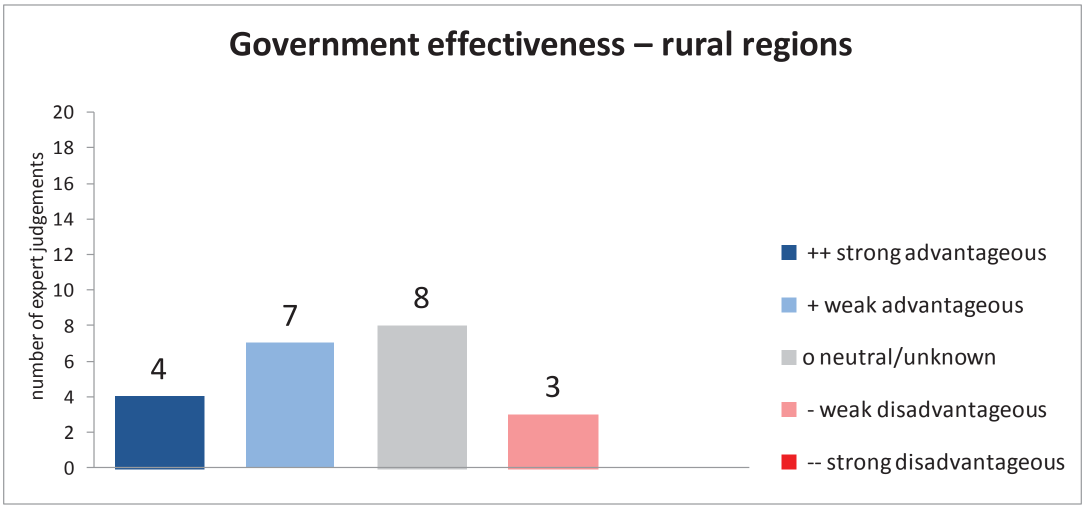
The experts considered that an efficient and correct implementation of the proposal to set minimum quality requirements for reused water in agricultural irrigation and aquifer recharge **could contribute to reduce administrative burdens**. However, if the implementation of the initiative is too complicated, its implementation could be very demanding for some regions as e.g. for islands. This diverging approach was reflected in the experts' votes on the effects of government effectiveness: A majority of experts is expecting positive effects but there is a quite large group that did not see any effects on government effectiveness, and a minority of experts that judged the effect as disadvantageous.

Figure 6.1: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on government effectiveness



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Figure 6.2: Workshop findings: Expert judgement: Effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on government effectiveness in rural regions

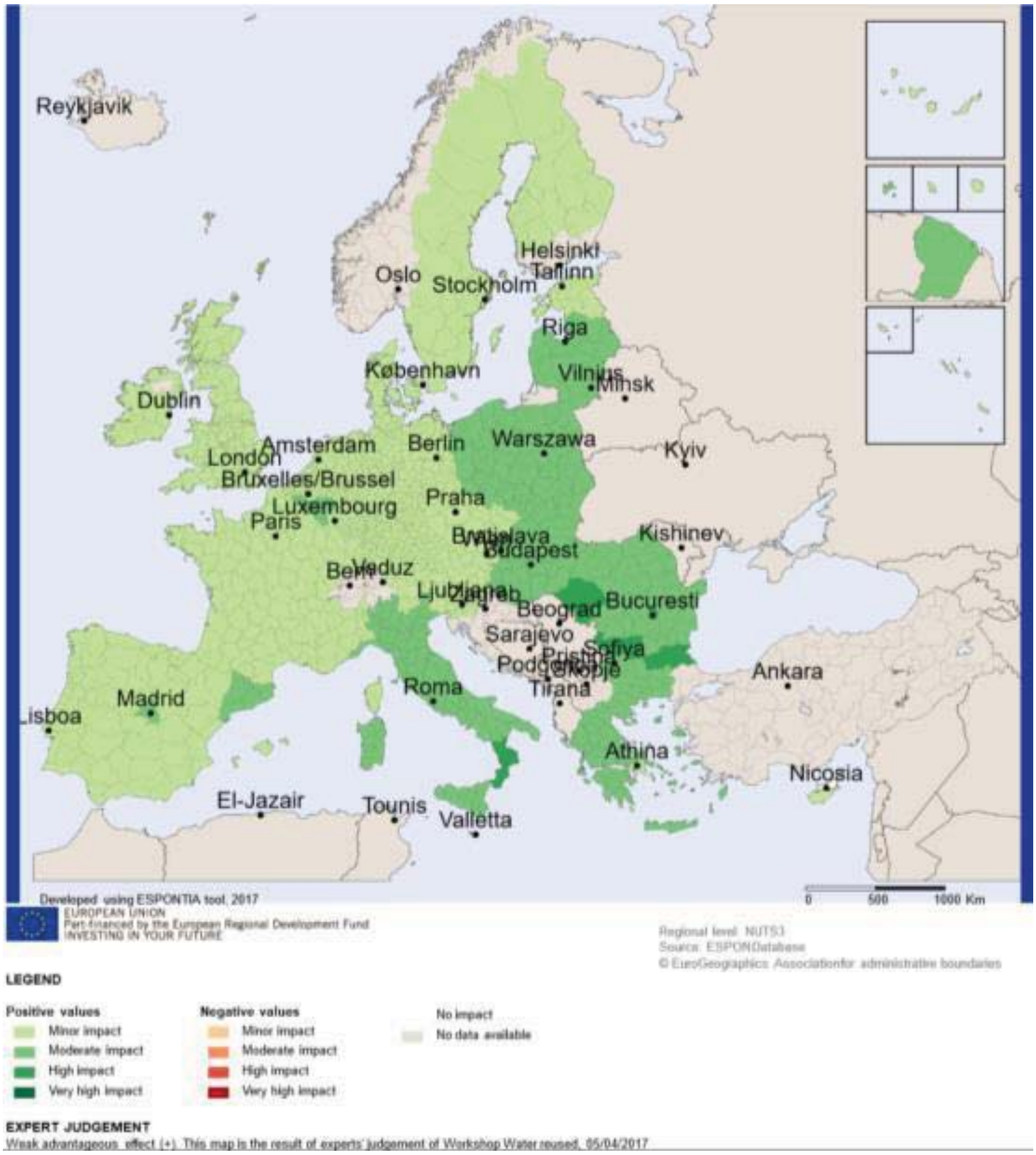


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

The sensitivity of government effectiveness is measured by the indicator being part of the Regional Competiveness Index. Regions with low government effectiveness will benefit more from the implementation of new standards of administration than regions that already have high standards of their administration.

The following map shows the potential territorial impact of setting minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on government effectiveness combining the expert judgement of the weakly advantageous effect with the corresponding sensitivity. Eastern European regions in Latvia, Lithuania, Poland, Romania and Bulgaria as well as Italian and Greek regions and some Spanish regions could gain a moderate to high positive impact on government effectiveness. Most of the other regions would gain a minor positive impact.

Map 6.1: Result of the expert judgement: Government effectiveness affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect



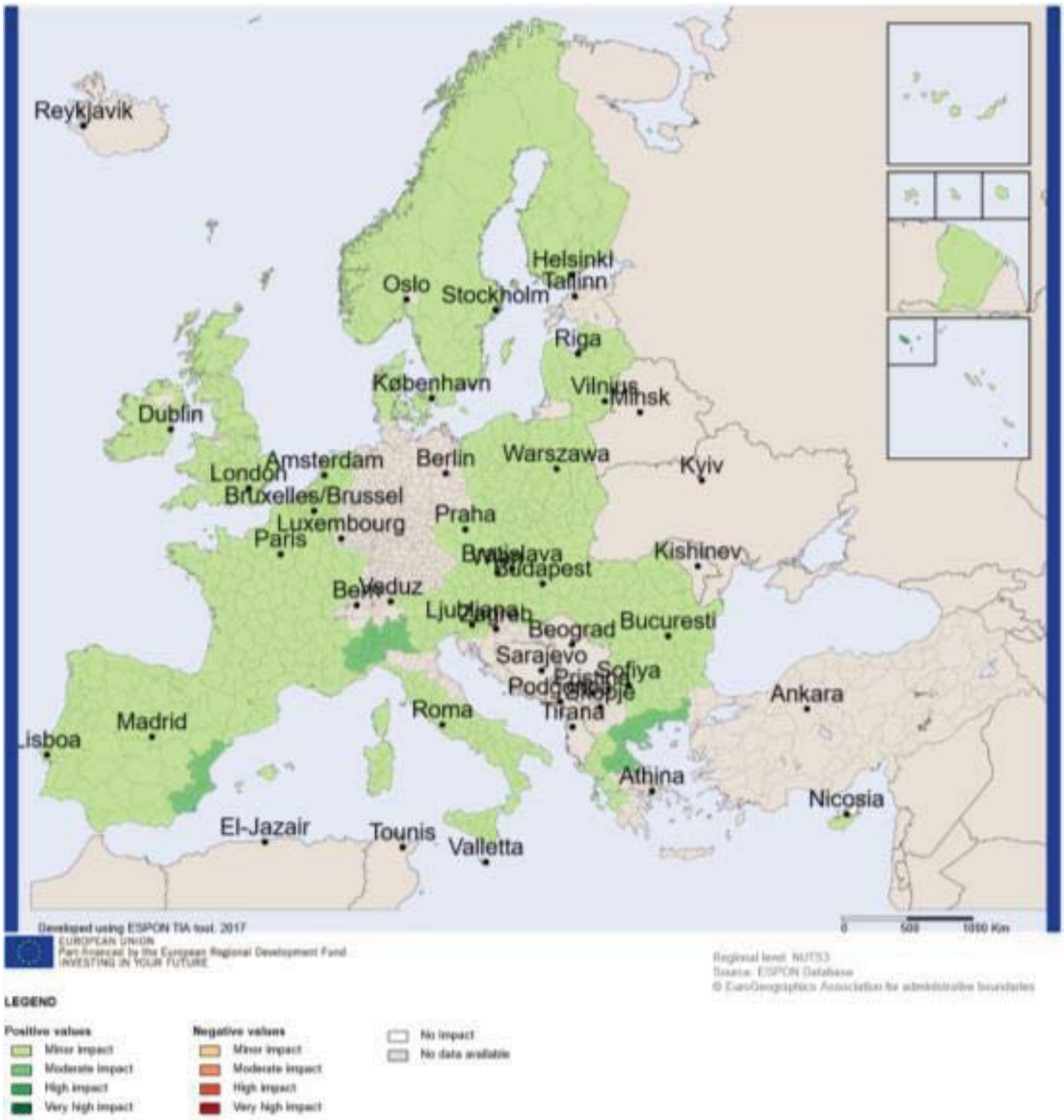
Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

7 Conclusions and policy implications

7.1 Findings based on the results of the TIA Quick check

The effects of setting minimum quality requirements for reused water in agricultural irrigation and aquifer recharge will mainly concentrate on regions with an important share of agriculture depending on irrigated land, and considering the experts expectation of a weakly advantageous effect, only 4.8% of the regions could generate a moderate or highly positive impact: Spanish regions on the Mediterranean coast, Greek regions on the Northern coast of the Aegean Sea and Italian regions around Torino. All other regions could gain just a minor positive impact.

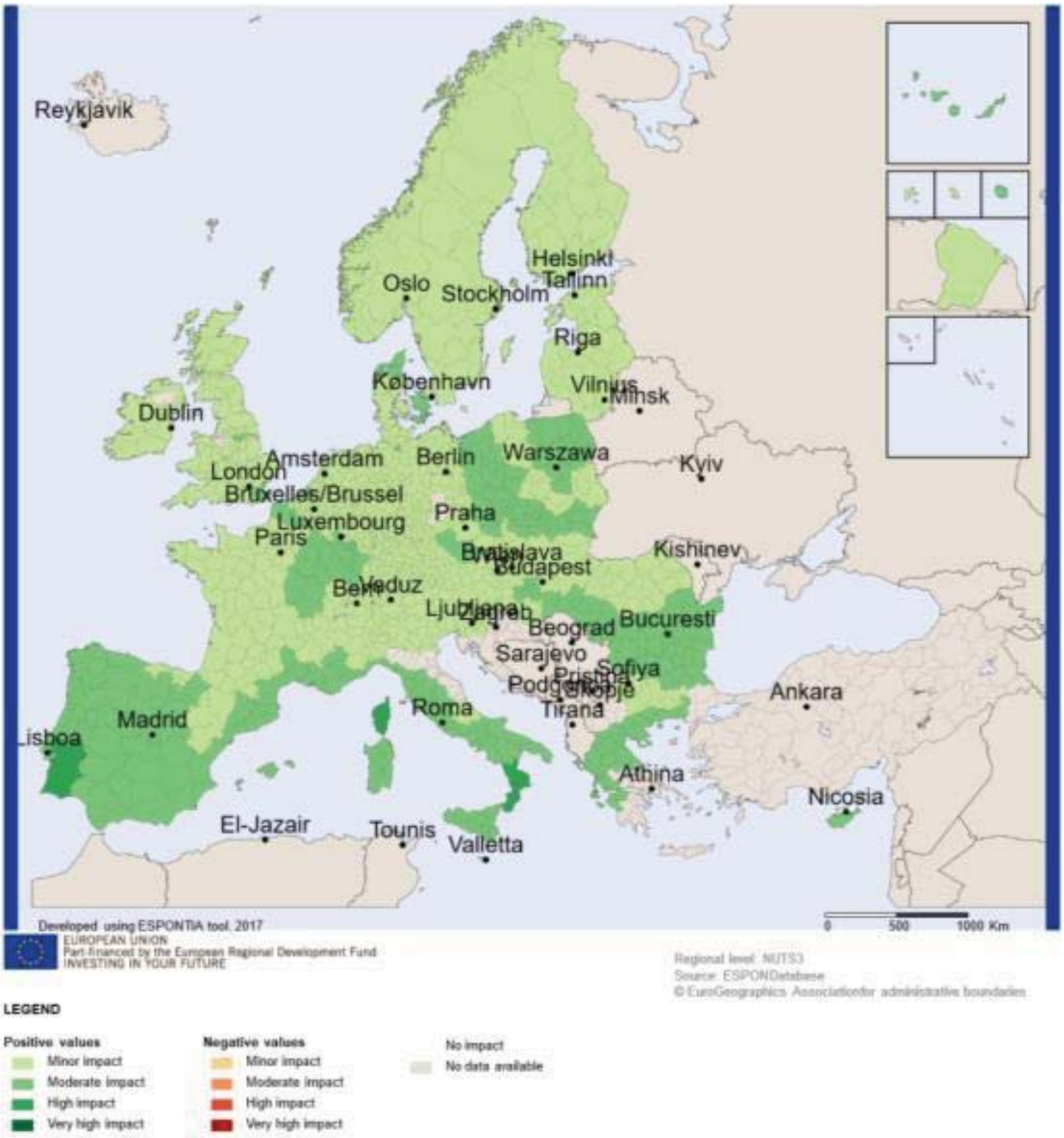
Map 7.1: Result of the expert judgement: Agriculture depending on irrigated land affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

<u>More benefits from setting minimum quality requirements for the reuse of wastewater and aquifer recharge would probably mainly concentrate on regions suffering from water scarcity, which are mainly regions endangered by droughts.</u> The majority of experts expected positive effects for such regions. The map combining the expert judgement of a weak advantageous effect with the corresponding sensitivity of regions facing droughts shows that **<u>about 24% of the regions could gain a moderate positive impact. They are situated in the South of Europe (Portugal, Spain, the Mediterranean coast of France, Italy, Greece, Cyprus) in East of Europe (East of Poland, South of Hungary, parts of Romania and Bulgaria) and in the centre of France. Only 1% of the regions located in the South of Portugal, in the very South of Italy and Haute-Corse could gain a high impact. The majority of 75% of the regions would face only a minor impact.</u>**

Map 7.2: Result of the expert judgement: Regions facing danger of droughts affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Taking into account that only 5% of regions with agriculture depending on irrigated land and about 25% of regions in danger of droughts are at least moderately impacted by setting minimum quality requirements for reused water in agricultural irrigation and aquifer recharge, it is quite clear, that **only a minority of NUTS 3 regions in Europe are currently challenged. These regions are mainly located in the South and the East of Europe.**

<u>However one should consider that the predictions for water scarcity and droughts are such that the situation will become more severe and the effects in the future could concern more parts of Europe.</u>

When looking at other potential territorial effects of setting minimum quality requirements for reused water in agricultural irrigation and aquifer recharge it has to be taken into account that these effects have been always considered under the presumption that the proposal will be actually applied for agriculture irrigation and aquifer recharge:

- The experts judged most effects of the development of minimum quality requirements for the reuse of wastewater and aquifer recharge weakly or even strongly advantageous. Just in a few cases negative effects were expected.
- Regions with a high economic importance of agriculture could gain positive effects on the GVA in agriculture as e.g. in Romania, Bulgaria, the North of Greece, the north East of Poland, in the centre of Spain and in the south of Portugal.
- Some peripheral regions mainly located at the European external borders could gain a highly positive impact reducing out-migration.
- Eastern European regions and some regions in Greece could potentially benefit with a highly positive impact on GDP growth.
- If the EU initiative is implemented efficiently and effectively, the regions in Latvia, Lithuania, Poland, Romania and Bulgaria as well as Italian and Greek regions and some Spanish regions could gain a moderate to high positive impact on government effectiveness.
- Outermost regions could benefit from catching up effects as e.g. considering economic growth or from the improvement of government effectiveness. However, a complicated regulation could be too demanding for its implementation considering the administrative capacity of the public services there.

7.2 Findings and recommendations from the expert discussion

Based on the maps showing potential territorial impact from the development of minimum quality requirements by linking the results of the expert judgements on the effects with the sensitivity of the regions towards these effects the experts discussed on conclusions and policy implications:

- Initiative contributes to strengthen European cohesion

<u>It was agreed that the EU initiative would definitely contribute to strengthen cohesion in EU, as it gives especially regions in the South and East of Europe the chance to gain positive effects on e.g. economy or government effectiveness. However, the positive effects will not be felt in the short term in regions where water is not scarce at the moment.</u>

- Quality standards

It was noted that the EU initiative must not lead to a reduction of existing ambitious water goals. The EU initiative would provide the possibility to opt for higher quality standards, especially in Member States with already existing higher water quality standards. It was clarified that the EU initiative will not undermine the standards set in the Urban Waste Water Treatment Directive and the Water Framework Directive. Is was proposed to think about a regional differentiation of the EU initiative.

- Implementation

When the goal is to increase the reuse of wastewater especially for agricultural irrigation the standard setting alone will not be sufficient. Additionally, subsidies for investment into irrigation could be relevant.

- Public acceptance

The setting of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge could improve the public acceptance of reused water, which could open chances for development, especially in rural areas. However, the EU initiative should be kept simple. The public would interpret a complicated regulation with long lists linking different quality standards to different types of use of wastewater as a sign that the reuse of water is environmentally dangerous. This could cause a problem with its public acceptance.

Annex 1: Territorial impact assessment workshop agenda

Territorial impact assessment expert workshop

Development of Minimum Quality Requirements for Reused Water in Agricultural Irrigation and Aquifer Recharge

Brussels, 5 April 2017

09.30 – 10:00	**Registration and Welcome Coffee**
10:00 – 10:05	**Welcome and introduction into the Territorial Impact Assessment** Eleftherios Stavropoulos Unit, Inclusive Growth, Urban and Territorial Development, DG REGIO
10:05 – 10:30	**Presentation of the Development of Minimum Quality Requirements for Reused Water in Agricultural Irrigation and Aquifer Recharge – Main issues – Policy Options** Thomas Petiguyot, DG ENV
10:30 – 10:45	**ESPON TIA Quick Scan tool** Erich Dallhammer, Austrian Institute for Regional Studies and Spatial Planning
10:45 – 12:30	Interactive discussion on **potential benefits of Developing Minimum Quality Requirements for Reused Water in the EU** with respect to the development of regions? § Dealing with cause/effect chains § Defining the types of regions affected and estimating the intensity of the regional exposure
12:30 – 13:30	Lunch Break
13:30 – 14:30	Interactive discussion on potential benefits of **Developing Minimum Quality Requirements for Reused Water in Agricultural Irrigation and Aquifer Recharge** with respect to the development of regions? § Discussion on the findings, results and hypothesis
14:30 – 15:30	**Policy recommendations**
15:30 – 15:45	**Summing up the results, feedback, discussion on options for further improvements**

Annex 2:
Description of the indicators used and regional sensitivity

Following the interactive discussion among experts, the following indicators were selected and introduced into the ESPON TIA Quick Check model:

Agriculture depending on irrigated land

Definition of sensitivity	**Regions where agriculture is depending stronger on irrigation are expected to be more sensitive towards policy proposals changing the precondition for irrigation.**
Description	Share of irrigated land of utilized agricultural area
Source	EUROSTAT
Reference year	2005
Original Indicator Spatial Reference	NUTS2, 2006

Regions facing danger of droughts

Definition of sensitivity	**Regions showing a higher danger of droughts are expected to be more sensitive towards policy proposals aiming at reducing negative effects of water scarcity.**
Description	The sensitivity of a region facing danger of droughts is measured by the probability of forest fires.
Source	ESPON project 1.3.1 "Spatial effects of natural and technological hazards."
Reference year	1997 – 2003
Original Indicator Spatial Reference	NUTS2, 2006

Regions facing heat waves

Definition of sensitivity	**Regions showing a higher chance of heat waves are expected to be more sensitive towards policy proposals aiming at reducing negative effects of heat waves than others.**
Description	days over 30 °C per year
Source	E-OBS
Reference year	1995
Original Indicator Spatial Reference	NUTS2, 2006

Pollutants in soil and ground/surface water

Definition of sensitivity	**The sensitivity of a region towards policies affecting the pollution of soil and ground and surface water is measured by a proxy indicator taking into account the population density and the employment density. Regions showing a higher density of land use are expected to be more sensitive towards policy proposals aiming at a reduction of soil and water pollution.**
Description	Population plus employment divided by the area of a NUTS Region is used as a proxy for high density land use
Source	EUROSTAT; ÖIR calculation
Reference year	2011
Original Indicator Spatial Reference	NUTS3, 2010

Added value in agriculture and forestry

Definition of sensitivity	**Regions where agriculture and forestry have an important share of the GVA are expected to benefit more from directives stimulating the added value in agriculture and forestry than others.**
Description	Share of agriculture and forestry in GVA
Source	EUROSTAT
Reference year	2010
Original Indicator Spatial Reference	NUTS2, 2006

Economic growth

Definition of sensitivity	**Regions with lower GDP per capita were expected to benefit more from directives aimed at GDP growth increase and that inadvertently harm economic growth. Sensitivity is thus inversely proportional to the level of GDP per capita**
Description	Gross domestic product (GDP) at current market prices; Purchasing Power Standard per inhabitant
Source	EUROSTAT
Reference year	2011
Original Indicator Spatial Reference	NUTS3, 2010

R&D Climate

Definition of sensitivity	**Regions with greater share of enterprises engaged in product and/or process innovation activities are considered to be more sensitive to directives influencing innovation.**
Description	Total intramural R&D expenditure (GERD), all sectors as a percentage of the GDP
Source	EUROSTAT
Reference year	2011
Original Indicator Spatial Reference	NUTS3, 2010

Employment in agriculture and forestry

Definition of sensitivity	**Regions with a greater share of employment in agriculture and forestry are likely to be more affected from changes in the level of employment in this sector of employment resulting from a directive.**
Description	share of employment in the sectors agriculture and forestry
Source	EUROSTAT, LFS, ÖIR calculation
Reference year	2014/15
Original Indicator Spatial Reference	NUTS2, 2006

Healthy life expectancy at birth

Definition of sensitivity	**Regions in which the life expectancy is lower are expected to benefit more from policy measures effecting its increase and more negatively influenced by those which decrease it.**
Description	Life expectancy at a given age (less than one year)
Source	EUROSTAT
Reference year	2012
Original Indicator Spatial Reference	NUTS3, 2010

Out-migration/brain drain/“shrinking” of regions

Definition of sensitivity	**Regions experiencing Out-migration/brain drain/“shrinking” of regions will benefit more from actions aimed at their reduction or suffer most from their exacerbation.**
Description	net migration balance (i.e. immigration minus out-migration on total population).
Source	EUROSTAT
Reference year	2012
Original Indicator Spatial Reference	NUTS3, 2010

Government effectiveness

Definition of sensitivity	**Regions with low government effectiveness as measured by the Regional Competiveness Index will benefit more from the implementation of new standards of administration than regions that already have high standards of their administration.**
Description	EU Regional Competiveness Index 2013
Source	DG Regio project on QoG
Reference year	2009
Original Indicator Spatial Reference	NUTS3, 2010

Definition of additional indicators

During the TIA quick check it is possible to identify additional fields of exposure, which are affected by the policy proposal and which are not provided by the tool as standard. Whereas the exposure caused by the policy proposal could be judged by the experts during the workshop, a valid indicator for describing the sensitivity of regions needs to be defined in advance. The TIA quick check offers the possibility to upload new indicators. It provides a template, where for each NUTS 3 regions the values of the indicator can be to be filled in.

For the new indicator it has to be defined, whether the exposure field needs to be evaluated as being either harmful (“cost”) or favourable (“benefit”) for the regions welfare. Then the tool will automatically transform the experts rating into numbers for further calculation (= normalisation).

Normalisation of indicators

The normalisation follows a linear procedure. Normalised values range from 0.75 up to 1.25. Basically, normalized sensitivity indicators represent coefficients that can increase (if greater than 1) or decrease (if lower than 1) each policy proposal's impact on a specific field.

Methodology for normalisation of regional sensitivity values

For this step the following definitions are needed:

$Xnorm_i$ the normalized value of the sensitivity indicator for impact field i

X_i the original value of the sensitivity indicator for impact field i

$Xmin_i$ the minimum original value of the sensitivity indicator for impact field i

$Xmax_i$ the maximum original value of the sensitivity indicator for impact field i

Then, normalization follows this formula:

$$Xnorm_i = 0{,}75+((1.25-0.75)*((X_i - Xmin_i)/(Xmax_i - Xmin_i)))$$

Source: ESPON TIA Quick Check Moderator's Guide and Methodological Background

Annex 3: The situation on the ground. Collection of replies of experts to questionnaire on waste water practices

Following the interactive discussion among experts during the workshop a series of questions were addressed in written afterwards to the participants in an effort to get a better idea regarding the situation on the ground around Europe regarding the:

- experience with water scarcity and water reuse
- potential for further uptake of water reuse and identified barriers

The following replies were received in written and are input from only a few of the experts that participated in the TIA workshop and represent their expert opinion and provide us a better idea of the situation on the ground. We observe that there is consistency between the input we got from the experts as reply to the detailed questionnaire and the conclusions of the TIA.

Experience with water scarcity and water reuse

- **Does your country/region/city face drought and water scarcity issues? What are the impacts, which are the impacted water uses and associated costs on water uses?**

In Greece approximately every 4-5 years there is a strong water stress on regional level in agricultural areas of Thessaly and Macedonia. The impacts are expressed in terms of yield decrease, and underground water losses due to considerable lowering of the water level, with the serious losses of the farmers income.

In Spain and especially in Murcia the climate characteristics with high temperatures all year round and the decrease of rainfall which is less than 4 hundred millimetres per year will intensify water scarcity. Murcia Region is in permanent drought. Annual rainfall is 300-350 mm, which is very low. The impact is very high, because agriculture is one of the most important sectors in the region.

Murcia has a complicated orography, because most of the territory is in a flat valley, and there are more than 180 pumping stations consuming energy to gather or collect sewage water and there are 15 Waste Water Treatment Plants and a long network of sewage pipes (1500 km). These are the reasons why water in Murcia is more expensive than in the rest of Spain, with prices being at a similar level as in the Canary Islands.

The Algarve region in Portugal occasionally faces scarcity situations owing the precipitation regime. According the Water Exploitation Index (WEI+), the region presents a moderate scarcity (27%). The storage capacity, namely in dams, allows the region to face droughts without significant impacts on socioeconomic activities except in specific situations of extreme droughts. The last extreme event was in 2005 and at that time it was necessary to restrict the water abstraction for agriculture irrigation. Other measures are also to reduce the water consumption in public supply and tourism activities. The impacts were not higher since the year 2006, which was a rainy one which allowed the natural aquifer recharge and the augmentation of surface storage.

The cost impact in 2005 for Algarve was significant due to the construction of infrastructures that ensured the use of several water sources for public supply and the increase of the treatment costs since some lower quality water sources had to be used. Other impacts were the reduction of some crop production due to irrigation constraints.

The general weather pattern in Romania is 2 dry years in a period of 10 years, but this pattern is changing due to the global climate change. So Romania is facing drought and water scarcity issues more often. Even in the normal weather years, there are areas confronted with local drought and water scarcity. Impacts are low water on the big rivers, including Danube, sometimes no water at all in the small rivers and lowering of the water table in the shallow aquifers. The impacted water uses are agriculture, drinking water supply, industrial water supply and ecosystems. The associated costs on the agricultural sector are calculated by the assurance companies and can be quite high, but the other water uses are not yet calculated.

The problem of draughts and water scarcity is of less importance in Germany that uses just 13% of its available water resources on average and is thus overall not facing water scarcity. Due to sufficient precipitation in the major part of the country there is also little need for irrigation – only around 1.5% of the overall water abstractions has been used for irrigation in 2012. In some regions, especially in the North-East of Lower Saxony, water scarcity is a crucial issue for agriculture. Experience with water reuse is available in the area of Braunschweig and Wolfsburg in the Lower Saxony. Agriculture is interested in realizing further projects of water reuse.

Despite this, potential additional water needs for irrigation on a local level are addressed by efficiency measures (e.g. technical measures or adaptations in cultivation practices) or by adaption of irrigation schemes. Periods of water scarcity causing impacts to human uses are rare in Germany. No costs and impacts are known on a national scale.

- **How do you foresee this situation will evolve in the medium term?**

Taking into account the climate changes and the increase of irrigated agriculture, the problem is expected to become more acute in Greece and Spain.

In Algarve/Portugal in a medium term significant impacts from water scarcity are not expected as a result of the construction of a new dam in 2012 that improved water availability in the region with an augmentation of 157 hm3 in storage volume. With this volume increase and the current management practices the regional authorities do not anticipate significant impacts from water scarcity, However, all agree that some uncertainties are related to this situation such as the climate change scenarios with prevalence to extreme events and abnormal increasing of water consumption due to a change in the dynamic of economic activities (e.g. increase in tourism rates and agriculture production).

In Romania there are some climate change scenarios developed by the National Institute for Hydrology and Water Management which show that in 30, 50 and 100 years period the extremes will accentuate (floods and droughts more severe).

Germany's water supply is considered secured in the long run. Nevertheless due to climatic changes the duration and frequencies of draughts can regionally increase in the future. This may lead to higher irrigation needs or challenges for cooling water supply in the energy sector. Overall water usage in Germany has been continually declining in the last years, with the exception of irrigation. In some regions, irrigation of agricultural products will increase.

- **Which are the measures presently implemented or planned for the close future in your country/region/city? Do these measures include development of additional water supply infrastructures and which are these? Are these measures included in a water scarcity plan?**

One basic measure in Greece is the gradual abandonment of the old traditional methods of irrigation and their replacement by drip irrigation of crops. The construction of small dams and small basins in drought afflicted areas such as in the islands for water collection, the use of resistant varieties to water stress. And all these measures are included in the water scarcity plan.

In Spain Portugal and Germany more attention is paid to managing the water demand and take measures to increase savings, water efficiency and promote good practices.

According to the experts from the city of Murcia they pay more attention to managing the water demand and take measures to increase savings, water efficiency and promote good practices as a way to anticipate droughts. Before applying water supply solutions to deal with water scarcity, all opportunities for managing and reducing demand must be exhausted. The city of Murcia contributes by making more efficient use of water. In order to avoid the risk that a more efficient use will result in a greater demand for the resource, it is imperative that measures to increase efficiency are accompanied by measures that ensure the sustainability of water use by ensuring that the water saved remains in the natural systems .

- Improvements in the water distribution network. Having a hydraulic yield of 86%.
- Promotion of the reuse of waste water, reducing pressure on watersheds. Reused waters should not be considered new resources but alternative resources.
- Establish an urban irrigation network with regenerated water from the WWTP, thus avoiding the depletion of the surface aquifer of Vega Media del Segura.

The city of Murcia has an emergency plan in case of drought situations and for the future they aim at

- A reuse of waste water for the irrigation of parks and gardens of the City of Murcia. Achieving a recovery in the surface aquifer of the Vega Media of Murcia, avoiding desalted water consumption with greater environmental impact and high energy use.
- Plan more green areas in the city as sustainable urban development.
- Continue to work on leaks, to achieve the highest possible yield in the distribution network.
- Reuse of waste water in agriculture, promote this measure, so that irrigators see the benefit and stop using desalinated water for irrigation, which is inefficient and costly.

Murcia region uses all the water sources that are available (Surface water, groundwater, water from other basins, reclaimed water, desalinated water). Most of the Waste Water Treatment Plants (WWTPs) in the region have tertiary treatment and there is also a big desalination plant. The region will need to build tertiary treatments for all WWTP and build more desalination plants.

In Algarve/Portugal the core existent and previewed measures are related with the water demand management, through the promotion of an efficient water use, reduction of losses and public campaigns to improve the consumption. The construction of new infrastructure (dams) is not foreseen. However, some investments are to optimize the existent ones and to integrate the existent uses of ground and surface water sources. These measures are described in several plans at national level (such as the National Program for the Water Efficient Use PNUEA and the Strategic Plan PENSAAR 2020) and at regional level (such as the River Basin Management Plans and contingency plans from the water supply management company). In addition the use of other sources, such as water reuse, is increasing with potential to improve its uptake and is included in the River Basin Management Plans.

In Romania emphasis is put in water saving campaigns developed by municipalities; and implementing new water supply infrastructures, mainly in rural areas. In addition water supply restrictions plan is activated during water deficit periods, approved by ministerial order.

In Germany water abstraction requires legal permit. Register of water rights and monitoring schemes for water level control are in place. Increasing water demand is mostly met by demand management, especially measures to increase efficiency.

According to the German climate adaptation strategy the following measures can be considered following a thorough assessment

- usage of grey water, rain water or process water for technical and industrial purposes not requiring drinking water quality
- further development of water saving methods especially in commercial and industrial production processes
- prevention of water losses in the distribution network
- more efficient cooling in power station
- reduction of water losses in agricultural irrigation
- use of highly treated waste water that is safe for health and environment for irrigation

The focus of administration bodies of Germany is on demand management measures. Private activities may include additional infrastructures such as advanced irrigation techniques or rainwater storage. For public water supply alternative strategies are considered for potential water shortages (e.g. contingency interconnections of separate water supply networks, redundant distribution of water abstraction sites, use of groundwater close to surface).

There is no national water scarcity plan in Germany. Local low water management plans are in place in some regions and they are based on a prioritisation of water uses. Measures depend on local circumstances.

- **How equipped with waste water treatment facilities is your country/region/city? To which extent and for which uses?**

There seems to be fairly good infrastructure for waste water treatment in the EU. For example in Greece currently about 320 Waste Water Treatment Plants operate at a national level where the wastewater is being treated at the second degree.

In the region of Murcia in Spain WWTR cover 99,3% of the population and in the City of Murcia in Spain there are 54 small population centers that are interconnected by a sewage network of 1,800 km and 15 waste water treatment plants. The municipal sewage treatment plants of Murcia have biological treatments, MBR treatments and as tertiary disinfection is used in some of them, achieving limits suitable for the uses named in the REAL DECREE 1620/2007, of December 7, establishing the legal regime for the reuse of purified water. Current uses are agricultural, recreational, environmental use and public stream.

Portugal has a high level of urban waste water treatment facilities which cover 90,3% of the population. Algarve region has one the highest rate of urban treatment facilities, about 95% of the population is covered by drainage and treatment facilities. The industrial wastewater production in Algarve is not significant and the majority of these are related with services and commercial activities connected to urban systems.

In Romania they are working to implement Water Treatment Directive for all the localities over 2000 equivalent inhabitants, but still we have a tremendous work to do in order to provide secondary and tertiary treatment facilities for urban waste water treatment, particularly in rural areas where the level of endowment with waste water facilities is quite low. On the other hand, food and other industries are obliged by law to treat their waste water in order to retain pollutants, so they are well equipped.

Germany has a very high level of waste water treatment. More than 91% of the installed treatment capacities can be attributed to large treatment plants serving more than 10000 population equivalents. Compliance with UWTTD 100% (Art 3 and 5), 99.9% for Art 4. Phosphorous and nitrogen removal of German WWTP exceed the requirements of the UWWTD. Wastewater treatment is almost exclusively through biological waste water treatment (> 95% activated sludge process and removal of nitrogen and phosphorous).

Some Länder have added a so-called fourth treatment level in the UWWTP to eliminate micro pollutants, e.g. in sensitive areas. On a national level a micro pollutant strategy is in progress which will likely encourage further extension of treatment plants with additional treatment.

- **Do you already engage in regional cooperation for this issue? Would smaller municipalities consider entering into an agreement with larger municipalities within the same region for the collection and handling of waste water?**

Some smaller communities in Greece may cooperate with larger municipalities for the processing of the wastewaters.

The regional government in Murcia/Spain created ESAMUR, the public body of regional government which mainly guarantee the right operation of the waste water treatment plants in the whole region of Murcia. There is a high regional cooperation. Primary network drinkable water in all the region is managed by a public Company, and the same for WWTP.

This was already done in Algarve region in Portugal (Study “Algarve Saneamento Básico anos 2000”), where, near the coastline, the smaller urban systems were included in larger sewage treatment plants. However, in the inland municipalities with a low population rate, due to the distance and n.º of inhabitants the system integration is not feasible. On the other hand, some of these small wastewater treatment plants are located near agricultural areas and local solutions for the treated wastewater reuse may present best options.

In Romania regional operators for drinking water supply and urban waste water treatment are established and working.

In Germany facilitation of co-operation and - in some occasions - of fusion of WWTPs is part of the counseling and funding activities of some regional governments.

- **How informed are citizens in your region regarding the reuse of waste water? What is their perception about this practice?**

The wastewater reuse in Greece is in the process of experimentation. For the time being Greece has sufficient water to cover the various uses for crop irrigation, industrial use, domestic use etc. However the periodic water stress appearing rings the bell for the near future increased water demand, and therefore, the research that is currently in progress aims at establishing the basis for the safe waste water and environmentally oriented research on wastewater reuse.

The Greek citizens have not so far systematically been informed regarding reuse. No serious effort so far has been put towards this direction, since the reuse of the wastewater in Greece is not included in the irrigation practices. However, it must be mentioned that the treated wastewater has occasionally been reused for irrigation of non-food crops, such as for cotton at the periods of water stress in the plain of Thessaloniki, which corresponds to a very small percentage in relation to the total amount of natural water used for irrigation. This practice necessitates only the users.

The citizens of Murcia are very aware of any issue related to water, these are informed by both the City Council and the Autonomous Community of anything that has to do with scarcity and reuse of water. Farmers are most knowledgeable regarding the reuse of waste water issues. The farmers in Murcia ask for their concessions of reuse water to the administration. Currently of the 15 WWTP managed by Aguas de Murcia, 9 of them have a reuse concession, although the volume is low because the treatment plants that have adequate treatment are very small.

The level of information in Algarve/Portugal may not be high but according the characteristics of the region, from a general point of view, the reuse practice is well accepted. However, at local circumstances, namely in some touristic activities in the coastline, the perception could be negative when other water sources are available (e.g. groundwater with a low price compared with the treated wastewaters, which has transport and monitoring costs for end-users).

The level of information to citizens regarding reuse of waste water in Romania is low. It is mentioned however during the water saving campaigns. The perception is not favourable particularly due to the health safety concerns.

Due to the fact that in Germany - apart from two sites reuse of water - reuse of water is not practiced it is difficult to assess the perception of citizens. As there is no need for alternative water sources on a large scale, it can be expected that acceptance by citizens is limited (this was also evident in pilot studies e.g. KLIMZUG NORD).

Potential for further uptake of water reuse and identified barriers (to be addressed separately for agriculture irrigation and aquifer recharge*)*

- **Do you see a potential for further uptake of water reuse in your country/region/city for agriculture irrigation/aquifer recharge? For other uses? Who would be the beneficiaries? Can you provide an estimate for this potential and the related benefits?**

There seems to be a future increased potential in Greece for uptake of wastewater reuse in agricultural areas, since reused water is a good source of plant nutrients and therefore it can replace the fertilizers. The increase of demand for irrigation water and expected extension of the irrigated agriculture results from the ever increasing demand for agricultural products and especially biological products. In addition the reuse of aquifer recharges can be useful during the water stress periods when the level of the underground water is being lowered in Greece.

It is anticipated that in Greece the beneficiaries will be the farmers, the consumers and of course the environment. For the time being, an estimate could be misleading due to the lack of actual data.

The reuse of water in Spain/Murcia is one of the axes of the development of the circular economy. Freshwater resources are increasingly low, with a disturbing mismatch between demand and availability of water resources at both a temporal and geographical level. In this context, the ability to respond to increasing risks of water scarcity and drying could be enhanced through greater reuse of treated wastewater. Adopting a series of measures to promote the reuse of treated wastewater, such as agriculture irrigation and also for garden areas, golf courses, urban uses and groundwater recharge, as well as investing in tertiary treatments to obtain water quality according to the EU minimum requirements are important.

The total water consumption in the Algarve region is about 200 hm^3 per year and the annual urban wastewater production as average around 40 hm^3, with the major production volumes in dry season, when the water demand is higher. However, the potential increase for water reuse should be more related with urban and recreational uses according the population distribution and the touristic character of the region. The aquifer recharge in Portugal is not foreseen since is not allowed according the Portuguese law. At national level, there is a potential for further uptake of water reuse for agriculture irrigation but in other regions rather than Algarve.

In Romania they foresee good potential for water reuse for agriculture irrigation of not eatable crops (textile and biofuel crops) and for cities green areas irrigation within dry periods. Romania has good quality groundwater bodies (in large aquifers), in good quantity status, used as drinking water sources, and they are very careful to preserve their status.

Beneficiaries in Romania will be not only farmers, but all citizens, because the reused water quantities will reduce restrictions during droughts.

In Germany there is no *general* need for alternative water resources in irrigation and aquifer recharge. An analysis showed that in most German regions the agricultural irrigation demand can be covered by available water resources without compromising the quantitative groundwater status. There are only a few districts in the Luneburg Heath and Upper Rhine lowlands that could benefit from additional irrigation with treated wastewater to stabilize their quantitative groundwater status (Seis et al, 2016).

Considering the potential risks of waste water reuse, the focus is on increased efficiency in case of temporary and regional shortages.

Since irrigation water is partly taken from surface waterbodies it already contains some of the treated waste water released into these river courses. Germany is focusing on a good waste water quality, so that the waste water can be discharged in surface water again. Releasing treated wastewater into rivers and streams provides for ecological minimum flows even in periods with low water levels.

The shift from combined sewer to separate wastewater/rainwater sewers introduced by federal law in 2010 leads to new opportunities to deal with collected rainwater in a way that also supports the local water cycle.

- **Which barriers to a wider uptake of water reuse solutions for agriculture irrigation/aquifer recharge do you identify in your country/region/city? Can you rank them according to their importance?**

The reluctance of the Greek public opinion towards the reuse due to perceived health risk effect and the fact that there is currently a relative sufficiency of irrigation water available in the country due to other techniques (river dams, artificial lakes for the collection of rain water etc). According to the experts from Murcia if the new minimum requirements would be more restrictive than the previous ones this will result that in some regions of the EU there will be a need to invest in existing and new waste water reuse treatments to reach the new requirements, which will lead to adoption of extraordinary charges for the local communities.

In Murcia region they perceive as the main barrier for agricultural irrigation the perception of other EU countries consumers, that don´t have confidence in the reclaimed water quality because of lack of knowledge about it .

In Murcia City they perceive as barrier the new investment that they anticipate as needed to comply with the new minimum quality requirements for reused water in agricultural irrigation and aquifer recharge that according to their estimates would amount to 870,000 € per 1 Hm3/year. At this cost they add the infrastructures needed to bring the reused water from the plant to the gardens (building a new irrigation network for water urban gardens: 5.950.000€.)

In Algarve/Portugal the following barriers have been identified:

- Distances between the point of production and point of end-use;
- Public authorities acceptance (e.g. health, agriculture and municipal authorities);
- Costs associated with some need to increase the treatment level and monitoring;
- Public acceptance (namely, when other water sources are available at a lower price, such as groundwater).

From a Romanian point of view a legislative barrier may arise since the prevention principle is basic for both environmental and health legislation (minimum quality requirements for water reuse should reflect this concern and guarantee the safety of reuse). On the other hand WFD do not allow the injection of waste water into the aquifers. In addition they consider the price as potential economic barrier. Good quality water should be available at a low price. Water monitoring costs will increase. Last but now least according to the Romanian expert citizen's acceptance (as consumer of goods irrigated with reused water and drinking water from the aquifers) is very low.

As there is no general need for water reuse in Germany, one cannot speak about "barriers" to its uptake. There is a lack of assessment criteria for unregulated substances that might be present in wastewater such as pollutants or microbiological contaminants that can impose a threat to groundwater quality when used for recharge or might adversely affect the soil. No quality standards for agricultural products irrigated with reclaimed water are in place.

- **Are there minimum quality requirements for water reuse that apply to agricultural irrigation/aquifer recharge in your country/region/city? Do you consider them appropriate as regards health and environment safety? Do you consider them a barrier to a wider uptake of water reuse and why?**

In Greece there are no official minimum quality requirements for reused water. The ones that exist are far from being minimum. The existing guidelines cannot help the farmer to accomplish the so called "safe reuse" as the health risk so far, has not been possible to be faced successfully. For the time being the wastewaters are not used for aquifer recharge in Greece. The minimum requirements, especially with regard to the wastewater heavy metal concentration are not considered appropriate as regards health and environmental protection**.**

Spain already has a regulation to regulate the requirements of the purified water for its reuse according to the different uses, called Royal Decree that establishes the legal regime of the reutilization of reclaimed waters. According to the Murcia Region expert the requirements they have are considered adequate to assure health and environment safety, because to their knowledge there were no epidemiological problems in all these years anywhere. They believe that stricter conditions - if they are affordable - can improve the consumers' confidence. The min. quality requirements may become a barrier if they are stricter that the ones already in place in Spain since the treatment price will become a barrier, but food health is also important according to the Murcia Region expert.

In Portugal there are national standards for waste water but they are not binding. However, a permit is needed for water reuse and in that procedure binding quality standards are applied in a case-by-case approach according the use, the barriers in presence, the vulnerability/sensitivity of the surrounding environment (soils and water bodies) and the risks to public health and environment (and crops in agriculture irrigation). In resume, binding values are defined in permits through a fit-for-purpose approach.

There no minimum quality requirements for water reuse that apply to agricultural irrigation/aquifer recharge in Romania. For the time being there is no treated waste water reuse in agriculture irrigation and aquifer recharge in Romania and there are no minimum quality requirements in place. At this stage (JRC study) Romania considers setting quality requirements for reuse of waste of water as problematic/not appropriate as regards health and environment safety, especially concerning aquifer recharge.

In Germany precautionary principle and prohibition of deterioration (WFD, GWD) are guiding principles for water resource management. There are no explicit quality requirements for water reuse as there is no overall need for this practice. There are norms for hygienic aspects of any irrigation water (DIN 19650) not specifically addressing reclaimed water.

For groundwater recharge quality thresholds of the Groundwater Ordinance (GrwV) would be the yardstick. Groundwater recharge would need a permit complying with national and federal water rights. In due course of issuing a permit, § 48 WHG and local circumstances will require an in-depth assessment and will lead to individual preconditions for the recharge activity.

The Federal Soil Protection Act and the Federal Soil Protection and Contaminated Sites Ordinance have the purpose to sustainably secure or restore soil functions. Negative effects on soil must be avoided, and such negative effects on soils must be rehabilitated.

- **Does size and geographic location of the municipalities/regions provide barriers to effective enforcement of the minimum requirements? How is your region/city handling the requirement of certifying the quality of the waste water and monitoring the respect of the minimum requirements, if any?**

According to the Greek expert the size of the Municipality could provide barriers for effective enforcement of the minimum requirement. If is something that the expert from Murcia Region shares as an opinion since for a small WWTPs is difficult to guarantee too strict requirements. A differentiated approach for small size WWTPs should be taken into account. In addition according to the Greek expert the geographic location may impose barriers if the waste water treatment plant is far away from the site of wastewater application as it may increase the cost of transportation.

In Spain the minimum requirements are controlled by the Health Authority and also Regional Sanitation Authority controls the correct operation of the facilities.

Size of municipalities and geographic location of waste water treatment plants in Romania were not studied related to water reuse.

- **Do you think the difference in minimum quality requirements across the EU is a barrier to a wider uptake of water reuse? If so, why do you consider differences in minimum quality requirements between Member States as a barrier?**

The Murcia city and region experts in Spain consider that differences in the requirements for reuse of reclaimed water can be an important barrier to the export of agricultural products and therefore agree with the proposal of DG ENV to set EU min. quality requirements. The same applies for Romania.

Algarve/Portugal consider that the difference in minimum quality requirements across the EU could only be a barrier to some public perception, since, for someone this aspect could present a suspicion about lower quality practices. This aspect also is a concern in Romania.

In Germany there is no wider uptake of reuse due to the low necessity.

- **Do you see a need for complementary measures, like information campaigns to inform citizens to reach better acceptance of water reuse?**

Greek, Spanish and Portuguese and Romanian experts consider necessary to inform the society about the reuse of wastewater by organizing systematic campaigns. Citizens are able to understand everything if they are well explained. Information campaigns for general public and dedicated campaigns/technical workshops for specific public (such as end-users, public authorities, NGO) could be delivered to improve knowledge and subsequently a better understanding of the practice and its acceptance. Citizens visits to wastewater treatment plants where they can see the work and the quality of the reclaimed water can change their perception of it.

According to the Murcia experts the inclusion of the word minimum in the title of the new initiative should be reconsidered mainly for two reasons:

- The new draft is more restrictive than the majority of state legislations for the reuse of reclaimed waters, so they would not be minimum requirements.
- The citizen's perception of the word minimum does not generate enough confidence, and would be detrimental to the necessary awareness and support of citizens to reuse water.

In Germany they do not consider any need for any complimentary measures due to lack of need to use reused water.

Impact of an EU initiative to promote water reuse (to be addressed separately for agriculture irrigation and aquifer recharge)

- **What do you think would be the best appropriate approach(es) of the European Union to promote water reuse in the EU (please rank them):**
  _ Impose water reuse to Member States, e.g. by setting targets to be achieved
  _ Establishing a common approach to water reuse across the EU by setting common minimum quality requirements
  _ Provide recommendations and guidance but leave Member States the entire responsibility to decide on the development of water reuse and minimum quality requirements

According to the Greek, the Algarve and Romanian experts the best appropriate approach for the EU would be to provide recommendations and guidance but leave Member States the entire responsibility to decide on the development of water reuse and minimum quality requirements according to their needs, tradition and social habits, Specific parameters and monitoring requirements need to be determined according the location and the purpose.

Therefore, the opportunity to deliver specific conditions at a River Basin level or at a case-by-case are required.

The German expert also considers option 3 as the most appropriate. As there is no acceptance for *imposing* water reuse – the necessity for it, its risks and conditions differ highly within the EU, thus implementing reuse should be decided within member states on the basis of necessity and site-specific conditions. Recommendations and guidance might help in regions with more frequent water scarcity issues. A guidance document that outlines a common approach to set appropriate minimum quality requirements that takes into account site-specific risks is more appropriate from a German point of view. However considering inter-European trade of agricultural products minimum requirements would have to meet a high standard to preserve food safety.

For the Murcia Region expert the best would be to establishing a common approach to water reuse across the EU by setting common minimum quality requirements. If this is not possible their second preferred option would be as in the case of Greek and Portuguese expert the option where the EU provides recommendations and guidance but leaves to Member States the entire responsibility to decide on the development of water reuse and minimum quality requirements.

In the case of option 2 the German expert underlined the need for very ambitious standards which should exceed existing legislation to ensure that reuse is safe for health and environment within the whole EU (including emission limit values!). Attention needs to be given to the highly differing quality of urban waste water (e.g. due to the share of industrial waste water being released into UWWTP and due to the level of treatment).

- **To which extent do you think EU Minimum Quality Requirements for Water Reuse in Agricultural Irrigation/Aquifer Recharge would help increase the uptake of water reuse in your country/region/city?**

According to the Greek expert to a relative extent since the requirements to his opinion will not help essentially to minimize the health risk effect, especially if the allowed levels for example of heavy metals remain high

According to the Algarve/PT expert the definitions of wide requirements instead of very strict values with guidelines and helpful campaigns would increase the confidence on the practice and promote its appliance.

The uptake will increase in Romania , but its extent is difficult to be foreseen. From a German point of view the uptake is related to the need and therefore since the need is low to zero EU minimum quality requirements will not have an impact on the need for water reuse.

- **To which extent do you think the above options, in particular the EU Minimum Quality Requirements for Water Reuse in Agricultural Irrigation/Aquifer Recharge would be a cost-effective means to increase the uptake of water reuse and therefore to tackle water scarcity in your country/region/city?**

Algarve/PT same as above.

Murcia region expert considers that there is a close correlation between the price of the necessary treatments. The Greek expert was not able to reply on this due to the lack of available data. In Romania the relationship of cost/efficiency is not clearly defined concerning Minimum Quality Requirements for Water Reuse in Agricultural Irrigation/Aquifer Recharge.

No impact is expected according to the German expert. Cost-effectiveness of reuse will mostly occur, if at all, in the long run since distribution networks would have to be built from the scrap. Due to the precautionary principle, aquifer recharge would require such a high quality of the reclaimed water that there is no overall cost- effectiveness expected at all.

- **In what way would EU Minimum Quality Requirements for Water Reuse in Agricultural Irrigation/Aquifer Recharge affect your country/region/city?**

According to the Algarve/PT expert if the EU Minimum Quality Requirements and the monitoring procedures are too strict and too long, respectively, the costs involved could be very high and difficult to support. Also the definition of long lists of parameters and strict values may cause some suspicion about the risk of the practice and jeopardize public acceptance.

Same concern was expressed by the Murcia City and Region experts that underlined that if the requirements are not affordable and their tertiary treatments aren´t able to get these values, the uptake will be lower due to price.

From a Romania perspective if DG ENV proposes a directive, it must be transposed and implemented by every MS, so national authorities could be forced to approve reuse in every case when minimum quality requirements are met, and this could jeopardize the objectives of other directives (Water Framework Directive, Groundwater Directive, Drinking Water Directive, Nitrates Directive).

From a German point of view this depends on the level of the requirements. Higher uptake of reuse could pose a threat of increased environmental pollution of soils and groundwater unless there are strict and ambitious standards for water reuse. Past experience with waste water earth catch areas (“Rieselfelder”) show high levels of contamination of soils and agricultural plants grown there.

- **How would citizens react to EU Minimum Quality Requirements in Agricultural Irrigation/Aquifer Recharge?**

According to the Greek expert probably positively. But as far as Greece is concerned, since reuse waste water is not a routine this question cannot be accurately addressed.

According to the Algarve/PT expert if there is a long lists of parameters and strict values are presented that may cause some suspicion about the risk of the practice and jeopardize public acceptance. But some wide requirements with guidelines and helpful campaigns would increase confidence in the practice.

The Murcia Region expert assumes that it will depend on the values of the requirements, with the necessary price for the treatments and the information campaigns to explain the changes about the actual situation.

Negative reactions are to be expected in Romania. In Germany reactions would depend on the level of standards, the kind of legal instrument and local conditions. In general little acceptance within the citizenship is expected.

Annex 10 - International trade dimension

Today, the planned used of treated wastewater is a common practice in countries of the Middle East and North Africa, Australia, the Mediterranean, as well as in Mexico, China and the USA (AQUASTAT, n.d.b.). However, there is no comprehensive inventory of the extent of treated or untreated wastewater used in agriculture, apart from the incipient efforts by institutions like AQUASTAT (n.d.b.). Inadequate wastewater treatment and the resulting large-scale water pollution suggest that the area irrigated with unsafe wastewater is probably ten times larger than the area using treated wastewater (Drechsel and Evans, 2010)[15].

Many different approaches are practiced to mitigate potential health risks resulting from treated wastewater used for irrigation. WHO Guidelines for the Safe Use of Wastewater, Ecreta and Greywater in Agriculture (WHO, 2006a) acknowledge the potential health risks of wastewater with no or inadequate treatment, and the necessity to reduce such risks. However, in developing countries, strict water quality standards for reuse are often perceived as unaffordable and therefore fail in practice.

Setting minimum quality requirements and a risk assessment approach for water reuse at the EU level is assumed to result in positive impacts on the international trade with third countries, as the European producers would rely on a safe and sustainable water supply option leading to a more sustainable agricultural production. In addition, European products could benefit from a comparatively good reputation as minimum quality requirements would ensure adequate safety of the products. A harmonised approach for all EU Member States would contribute towards a more informed and safer consumer choice, with positive impacts for both the Internal Market and internationally. The impacts on competition with imports from third countries are expected to be neutral, however, assuming absence of "subsidisation" for reused water, negative impacts could be expected where the price of agricultural production increases as a result of water reuse.

There is a rapidly growing world water technology market, which is estimated to be as large as EUR 1 trillion 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, and it is on the verge of major expansion and going forward is expected to outpace desalination. 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). Without any policy measures to incentivise / support the uptake of water reuse schemes, it is unlikely that the EU water reuse sector would be maturing at a faster rate. The absence of incentives for further water reuse would lead to no positive impact on competitiveness and innovation related to water reuse technologies. Considering the potential worth of this industry, this could lead to a loss of opportunities for the European market to be a leader on this issue.

[15] The United Nations World Water Development Report 2017 "Wastewater the untapped resource".

Figure 34: Evolution of 20 top EU Agri-food imports from Extra EU 28, 2012 – 2016

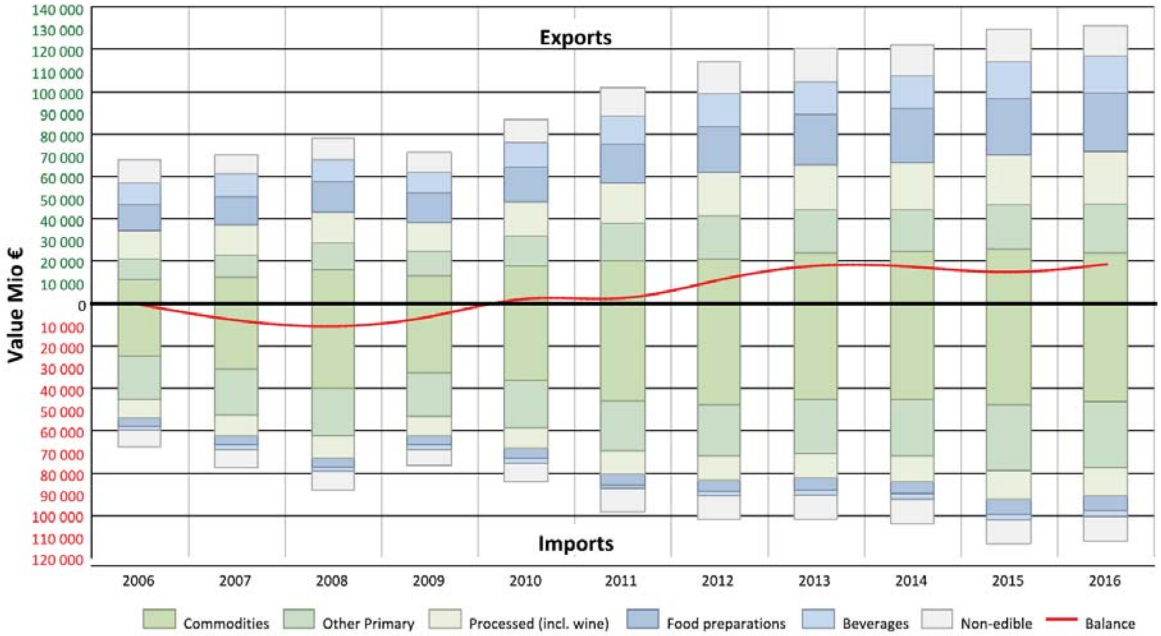
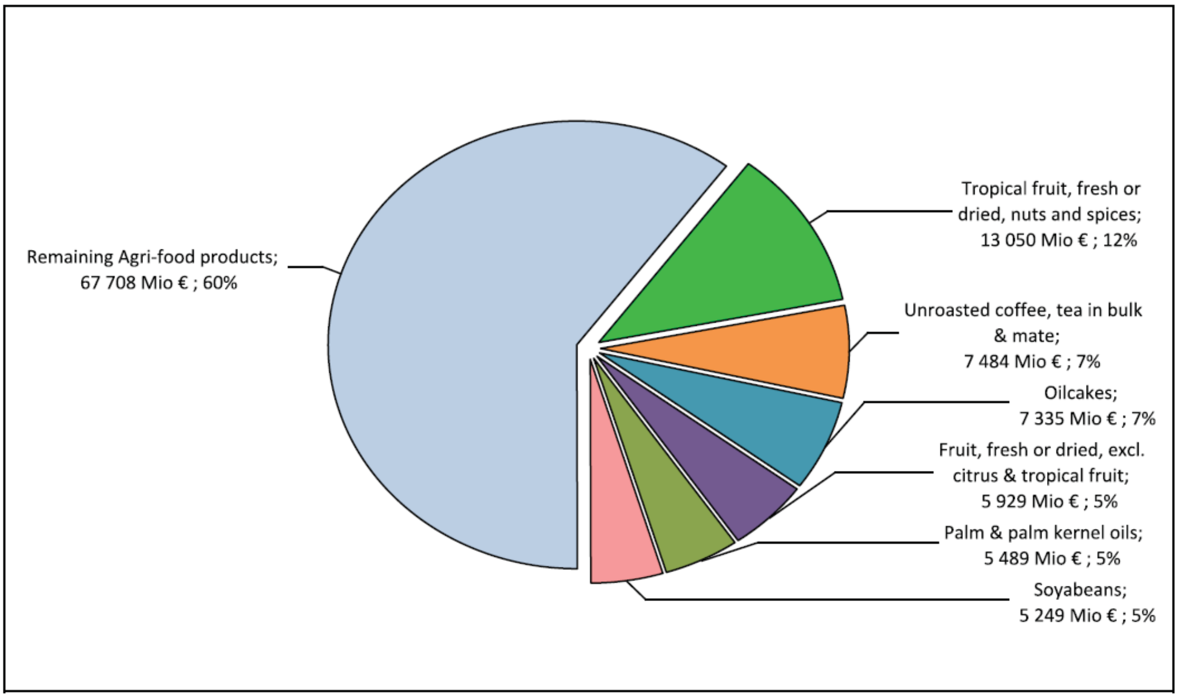


Figure 35: Top EU Agri-food imports from Extra EU 28 in 2016



Annex 11 – Subsidiarity assessment of potential EU-level regulation of water reuse for aquifer recharge

As for agricultural irrigation, the use of reclaimed water for aquifer recharge is subject to existing requirements in EU legislation, in particular:

- the UWWTD, applied to the discharge of urban waste treatment plants to the environment (sensitive areas, catchments of sensitive areas, non-sensitive areas);
- the WFD, in particular Article 11(3)(f) which requires that artificial recharge or augmentation of groundwater bodies be subject to prior authorisation and that such actions do not compromise the achievement of objectives for the groundwater body; Article 11(3)(j) imposes the 'prohibition of direct discharges of pollutants into groundwater'; Article 7 imposes specific protection of water bodies used for the abstraction of drinking water;
- the Groundwater Directive, in particular Article 6 which states that the inputs of pollutants that are result of artificial recharge or augmentation of bodies of groundwater authorised in accordance with Article 11(3)(f) of the WFD may be exempted from measures to prevent inputs into groundwater of any hazardous substances, provided efficient monitoring of the bodies of groundwater concerned is in place;
- the EIA Directive, when the capacity of the urban wastewater treatment plant exceeds 150 000 population equivalent, or if the annual volume of water recharged exceeds 10 million cubic meters, or if artificial groundwater recharge is subject to an Environmental Impact Assessment in application of article 4(2) of Directive 2011/92/EU in the Member State.

The crucial difference of aquifer recharge relative to agricultural irrigation is that it does not directly entail any issue linked with the Internal Market.

The associated risks are very much dependent of the nature of the project (characteristics of the urban waste water to be reclaimed, technique for aquifer recharge) and the characteristics of the local environment (in particular of the aquifer in terms of its capacity to further improve reclaimed water quality). Therefore it has been found impossible to derive science-based minimum quality requirements for water reuse for aquifer recharge in terms of quality criteria (parameters and limit values) that would need to apply to every project in the EU in addition to the requirements from the existing legislative framework (cf. Annex 7). However, similarly to agricultural irrigation, when it comes to ensuring health and environmental protection, a risk management framework is widely considered the appropriate regulatory approach for water reuse projects for aquifer recharge, as it can ensure the desired level of protection against risks while leaving flexibility to adapt to specific conditions.

Based on the above, the most appropriate EU level response is Guidance on the implementation of a risk management framework for water reuse for aquifer recharge. Given the local nature of the aquifer recharge practices, the regulation of water reuse for aquifer recharge should remain the competence of Member States, while ensuring full compliance with the relevant existing legislation.

Annex 12 – Comparison of impacts per policy options and per different group of Member States

Options for agricultural irrigation	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
Baseline (agricultural irrigation & aquifer recharge)	Environmental: 0 (increased uptake in Spain but not in other MSs) Economic/Administrative: - /0 (increased costs of droughts in MSs affected if no action taken) Social: -/0		Environmental: 0 Economic/Administrative: 0 Social: -/0	
Ir3 – Guidance "fit-for-purpose" **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 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; Potentially reduced uptake due to more stringent standards depending whether cost is passed on to farmer) Economic: -/+ (increased costs of treatment if more advanced processes are needed; improved trade and business opportunities/ Administrative Risk assessments to be performed but less monitoring costs potentially) Social: + (public acceptance boosted)	Environmental: +/0 (increased water availability + reduced risks associated with environmental pollutants present in treated wastewater /no change) Economic: -/+ (increased costs to farmers or WWTP operators/ potential for increased uptake / improved trade and business opportunities) Administrative: administrative burden due to system to be set up for water reuse permitting Social: + (promotion of public acceptance)	Environmental: 0 Economic/ Administrative: 0 Social: 0

Options for agricultural irrigation	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
Ir1 – Legal instrument "one-size-fits-all" **Anticipated uptake: NEGATIVE (under 0,50 Eur/m3 scenario)**	**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
Ir2 – Legal instrument "fit-for-purpose" **Anticipated uptake: HIGH**	**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

Annex 13 – Abbreviations and Glossary

Agricultural irrigation	The application of controlled amounts of water to plants at needed intervals
Aquifer	An underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials from which groundwater can be extracted
Aquifer recharge	A hydrological process where water moves downward from the soil surface towards groundwater. Recharge occurs both naturally (through the water cycle) and man-induced (i.e. artificial aquifer recharge), where rainwater, surface water and/or reclaimed water is routed to the subsurface. Artificial groundwater recharge aims at increasing the groundwater potential and it can effectively help preventing saline intrusion in depleted coastal aquifers.
Associated Directives	(to the Water Framework Directive) Groundwater Directive and Priority Substances Directive
Blueprint	Commission Communication "A Blueprint to safeguard Europe's water resources COM(2012) 393
BREF	Best Available Technique Reference Document developed under the Industrial Emissions Directive
BWD	Bathing Water Directive
CAP	Common Agricultural Policy
Catchment area	Any area of land where precipitation collects and drains off into a common outlet, such as into a river, bay, or other body
CEC	Contaminant of emerging concern
CEN	European Committee for Standardization
Circular Economy Action Plan	Commission Communication "Closing the loop – an EU action plan for the circular economy COM(2015) 614
CIS	Common Implementation Strategy for the Water Framework Directive and Floods Directive
Discharge	The volume of water flowing through a river channel at any given point (measured in cubic metres per second)
Drought	A period of below-average precipitation in a given region, resulting in prolonged shortages in the water supply, whether atmospheric, surface water or ground water
DWD	Drinking Water Directive
Effluent	Wastewater - treated or untreated - that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters
EC	European Commission
EEA	European Environment Agency

EFSA	European Food Safety Authority
EIA Directive	Environmental Impact Assessment Directive
EU	European Union
Fertigation	Irrigation with nutrient rich water but free from other pollutants
GHG emissions	Green House Gas emissions
ICT	Information and communication technology
IED	Industrial Emissions Directive
Internal Market	EU single market in which the free movement of goods, services, capital and persons is assured, and in which citizens are free to live, work, study and do business.
Ir	Irrigation
JRC	Joint Research Centre (European Commission)
Membrane bioreactor	Specific water treatment technology
Micro-filtration	Specific water treatment technology
MSFD	Marine Strategy Framework Directive
N	Nitrogen
NUTS2	Nomenclature of territorial units for statistical purposes - second level regions
Reverse osmosis	Specific water treatment technology
RBD	River Basin District
RBMP	River Basin Management Plan
Saline intrusion	The movement of saline water into freshwater aquifers, which can lead to contamination of drinking water sources and other consequences
SCHEER	Scientific Committee on Health, Environmental and Emerging Risks
SDGs	Sustainable Development Goals
SME	Small and Medium Sized Enterprise
Streamflow	The flow of water in rivers, streams and other channels
TIA	Territorial Impact Assessment
Ultrafiltration	Specific water treatment technology
Ultra-violet disinfection	Specific water treatment technology
Water abstraction	The process of taking water from a ground or surface source, either temporarily or permanently.
Water appropriation	The capture, impounding, or diversion of water from its natural course or channel and its actual application to some beneficial use to the appropriator to the exclusion of other persons

Water reuse	The use of water which is generated from wastewater and which, after the necessary treatment, achieves a quality that is appropriate for its intended uses (taking account of the health and environment risks and local and EU legislation).
Water scarcity	The lack of sufficient available water resources to meet water needs within a region.
Water stress	The demand for water exceeding the available amount during a certain period or poor quality restricting its use.
WEI+	Water Exploitation Index
WFD	Water Framework Directive
WHO	World Health Organization
WS&D	Water Scarcity and Droughts
WSSTP	Water Supply and Sanitation Technology Platform
UWWTD	Urban Wastewater Treatment Directive