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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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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).

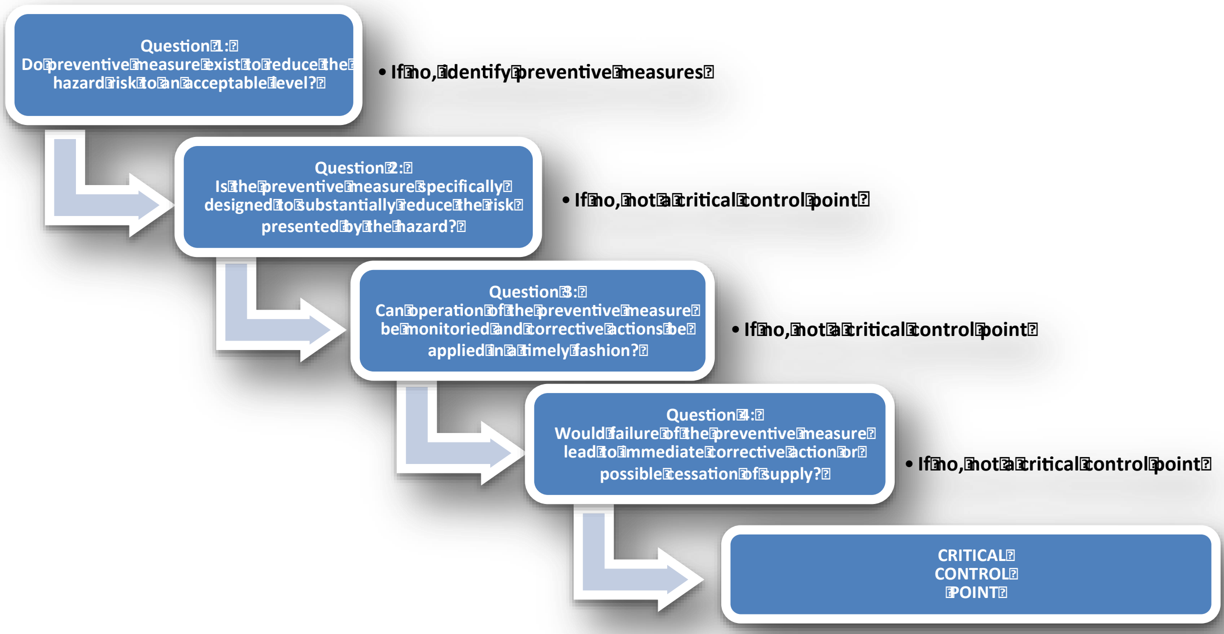
— The wastewater treatments included in the WWTP.

— 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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Annex

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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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.

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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:

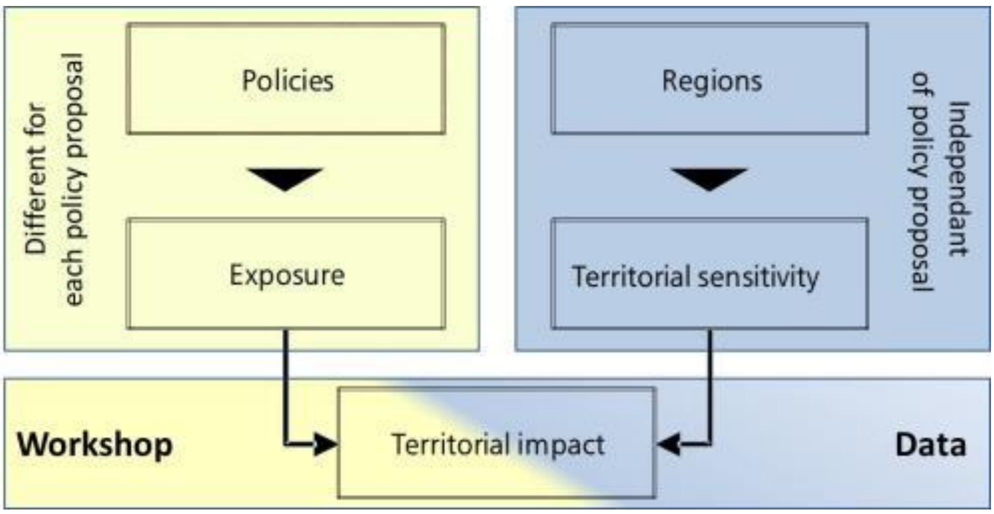
- ++ strong advantageous effect on territorial welfare (strong increase)
- +weak advantageous effect on territorial welfare (increase)
- O no effect/unknown effect/effect cannot be specified
- - weak disadvantageous effect on territorial welfare (decrease)
- - - strong disadvantageous effect on territorial 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

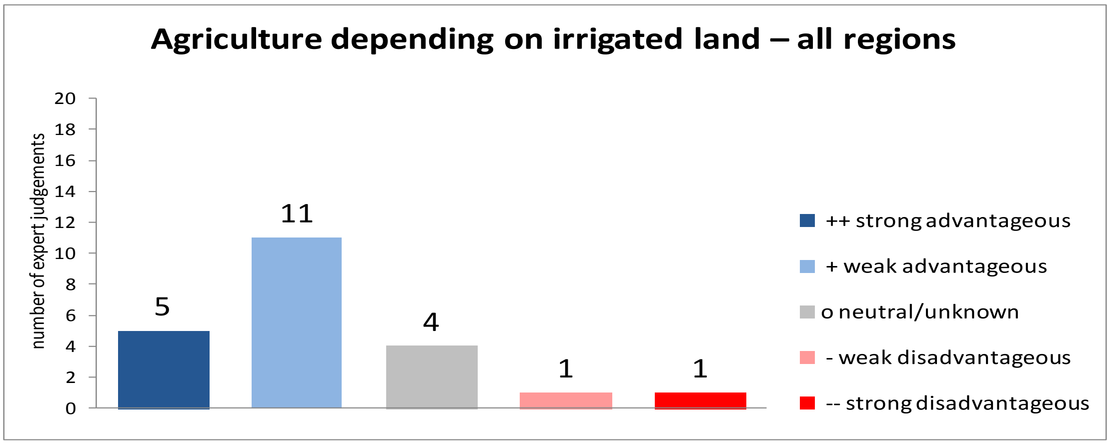
The result of the potential territorial impact assessment is presented in maps. The maps displayed below show the potential territorial impact based on a combination of the expert judgement on the exposure with the territorial sensitivity of a region, described by a indicator on NUTS3 level. Whereas 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

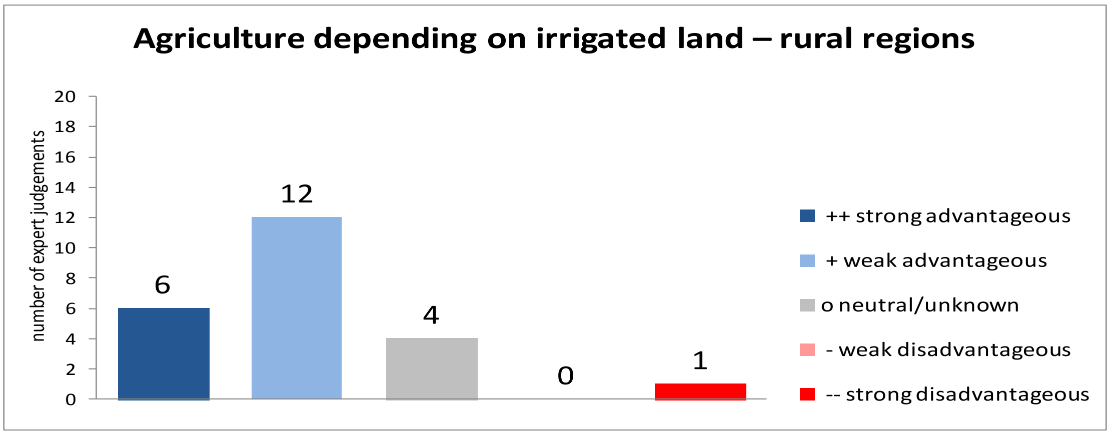
The experts agreed that the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge would definitely cause positive effects in all regions with agriculture depending on irrigated land. Five experts voted for a strongly advantageous effect, eleven for 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

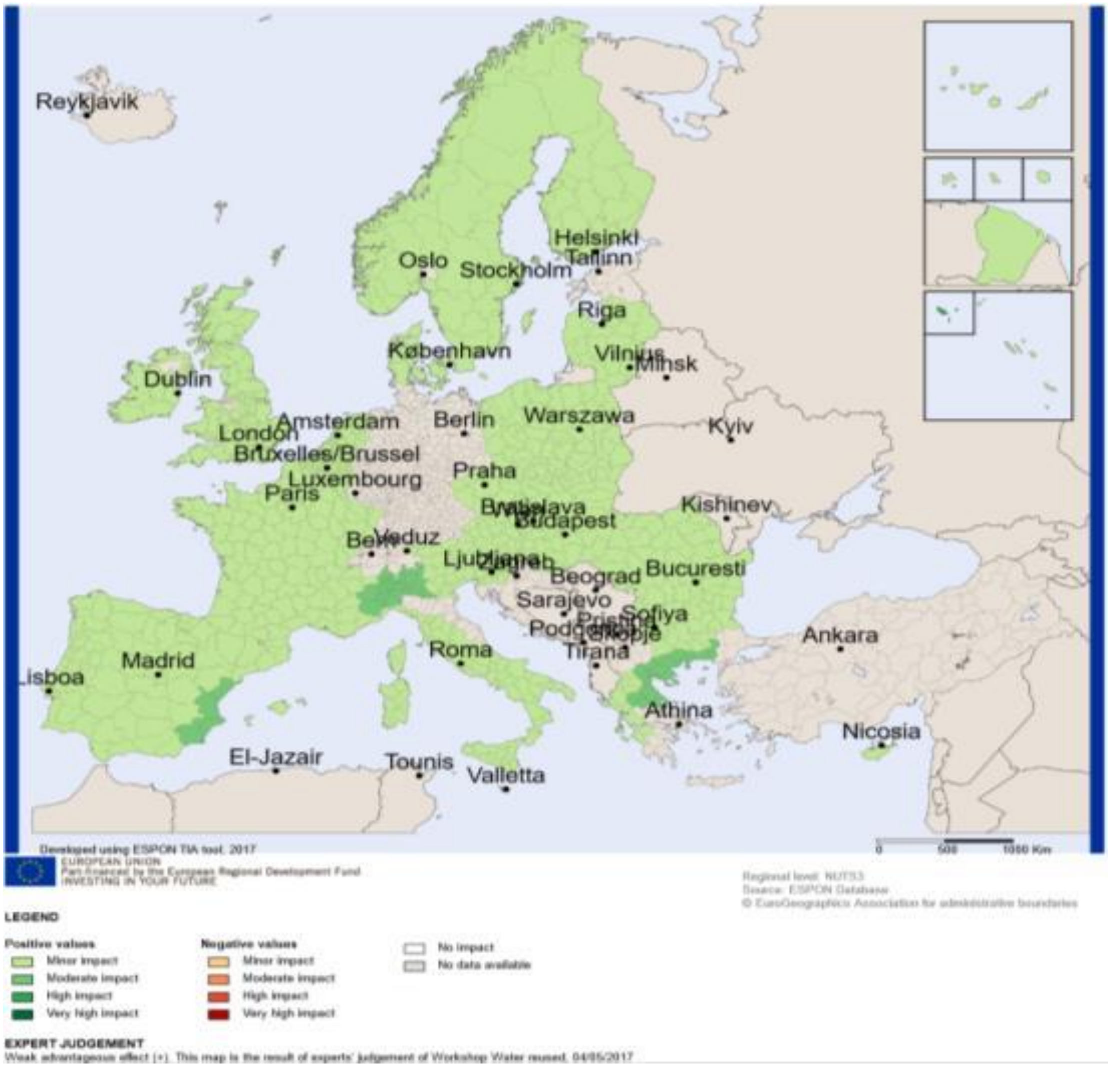


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

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

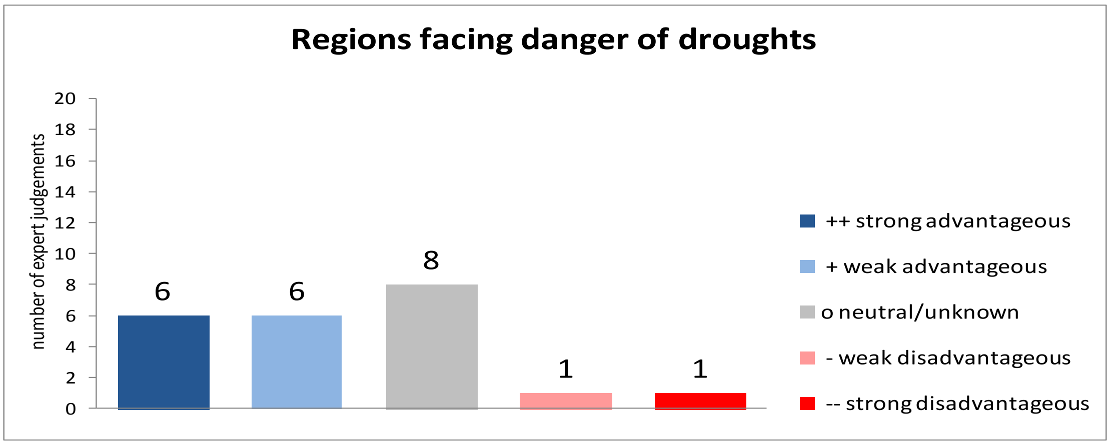


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

3.2 The potential territorial impact on regions facing danger of droughts

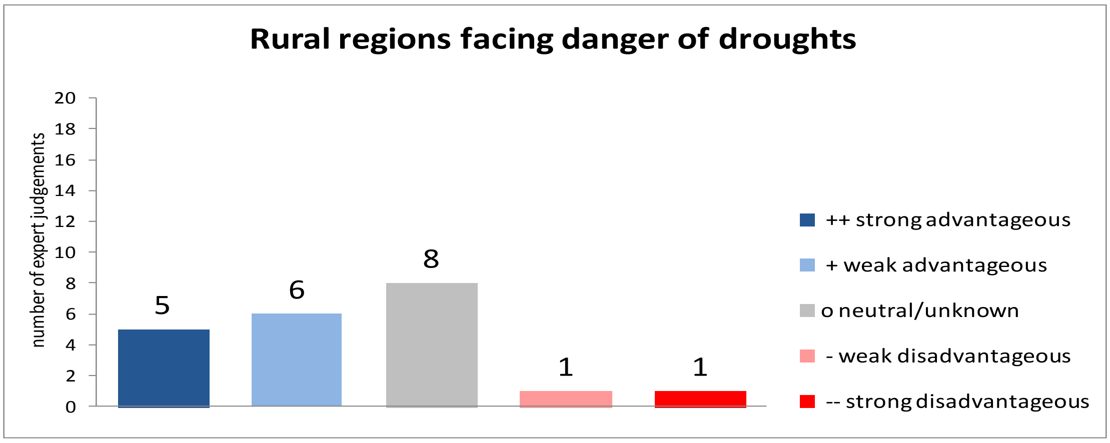
The experts estimated that the implementation of the EU initiative setting minimum quality requirements for reused water in agricultural irrigation and aquifer recharge could contribute to reduce the lack of water in those regions that are suffering from water scarcity. According to the experts it could 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



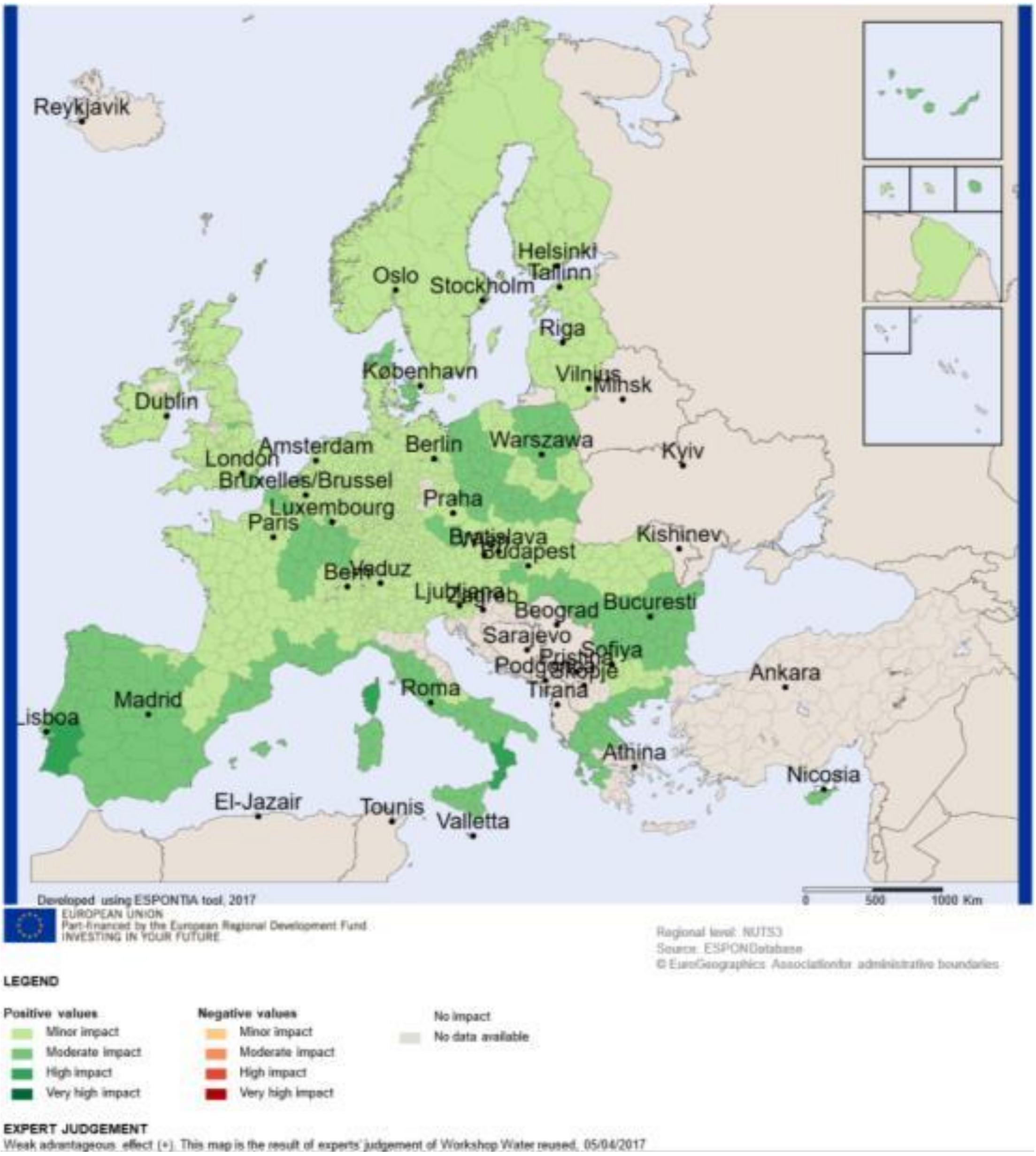
Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

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.

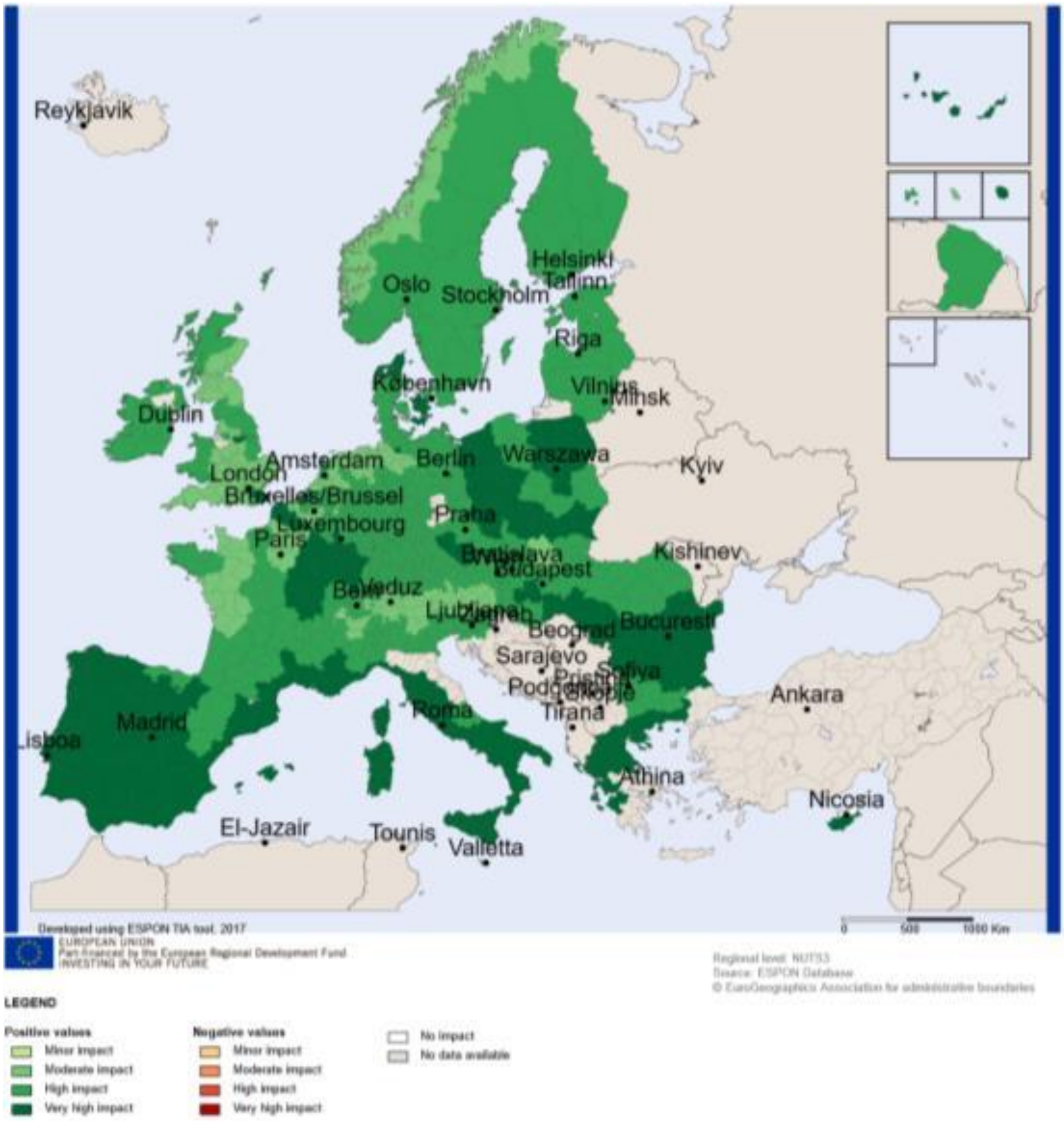
In case of the expert judgement of a strong advantageous effect the impact on the regions would be respectively higher, up to a very high impact for regions in the South and East of Europe.

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



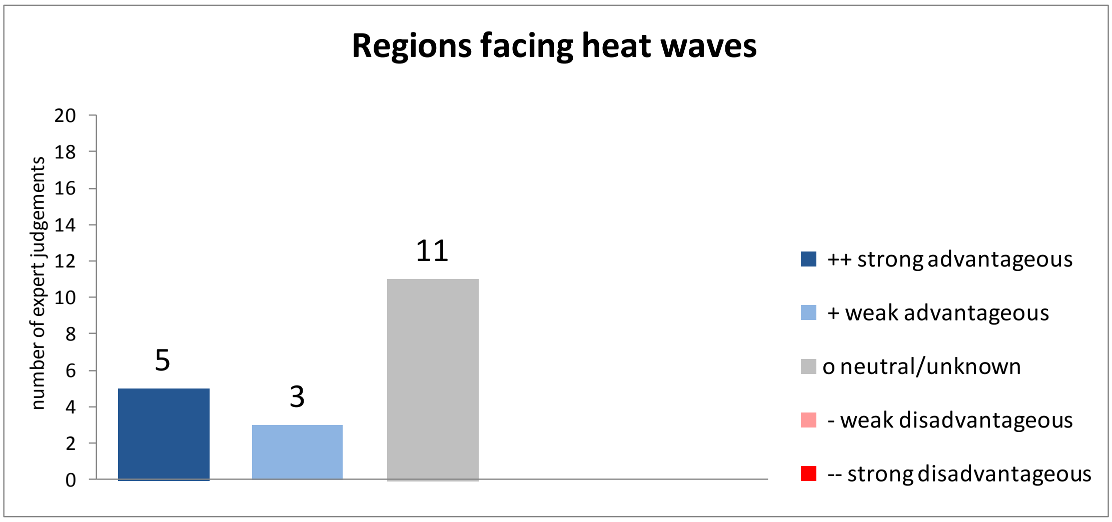
Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

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.

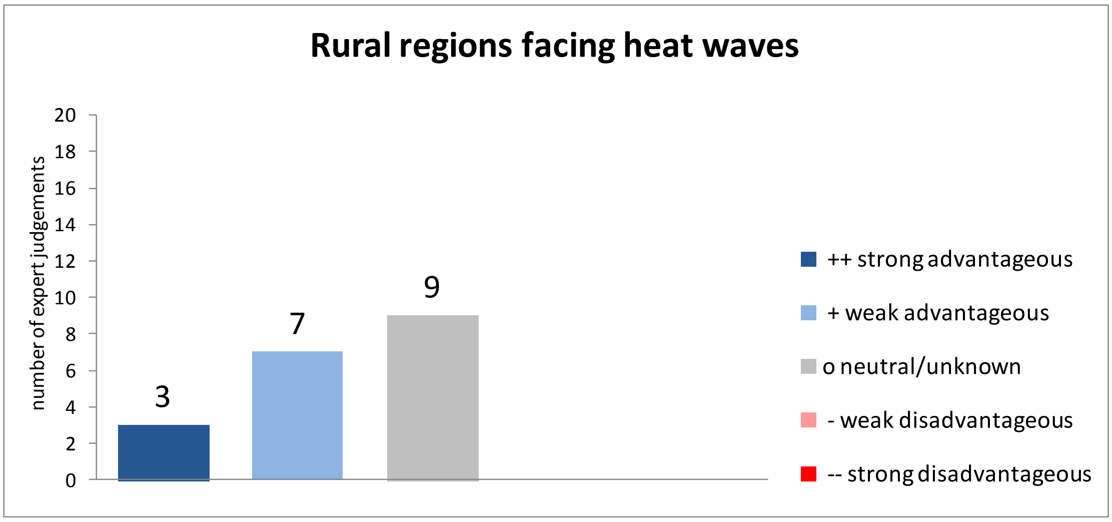
The indicator picturing the sensitivity of a region facing heat waves was measured by the number of days over 30 °C. This indicator was criticized by several experts, because they judged the cause-effect relation between the additional options for irrigation reducing the negative effects of heat waves 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

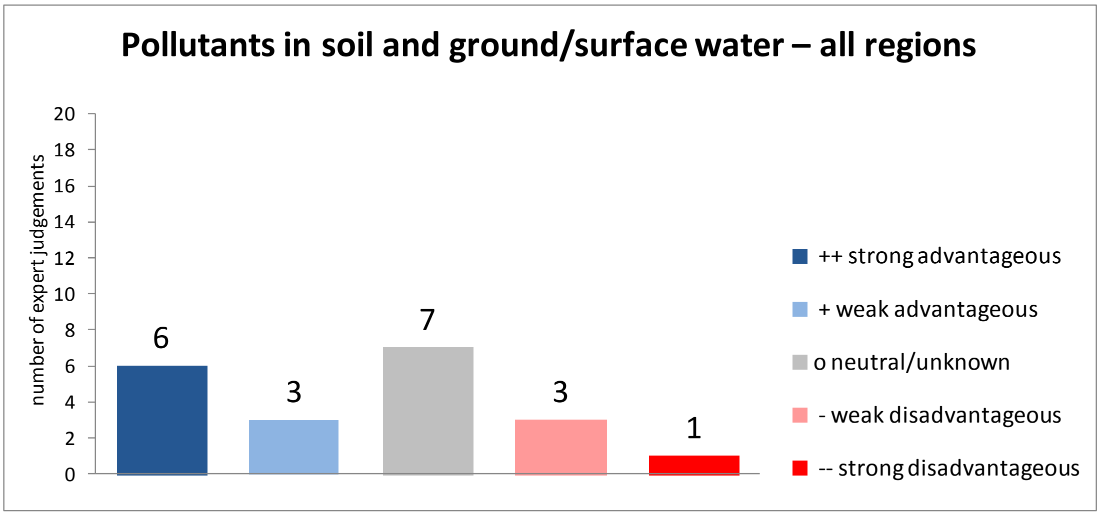


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

3.4 The potential territorial impact based on pollutants in soil and ground/surface water indicator

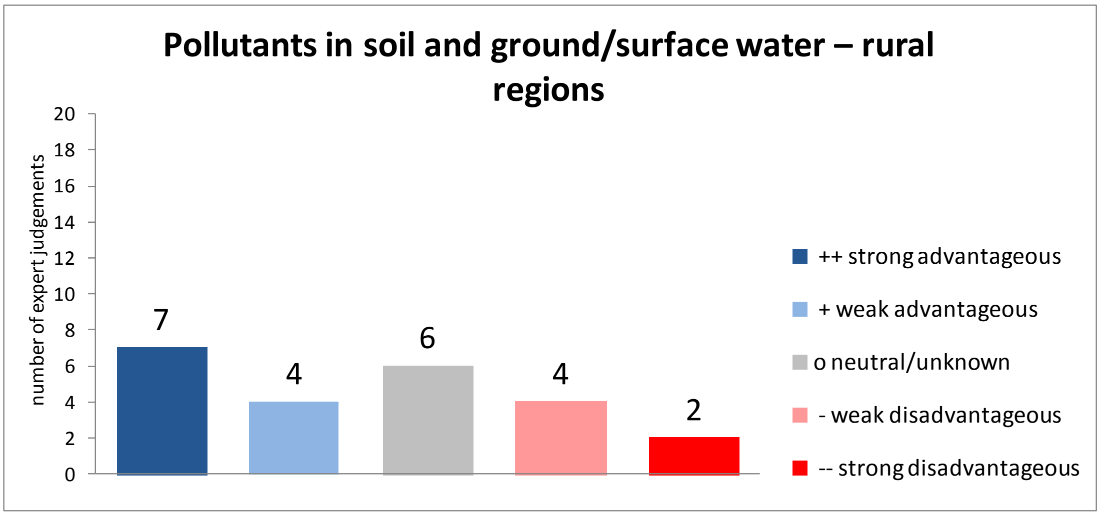
The experts' opinion on the potential effects of the EU initiative based on the indicator pollutants in soil and ground/surface water was quite diverging. A majority of them judged the effects as strongly advantageous (6 for all regions, 7 for rural regions) or weakly advantageous (3 for all regions, 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

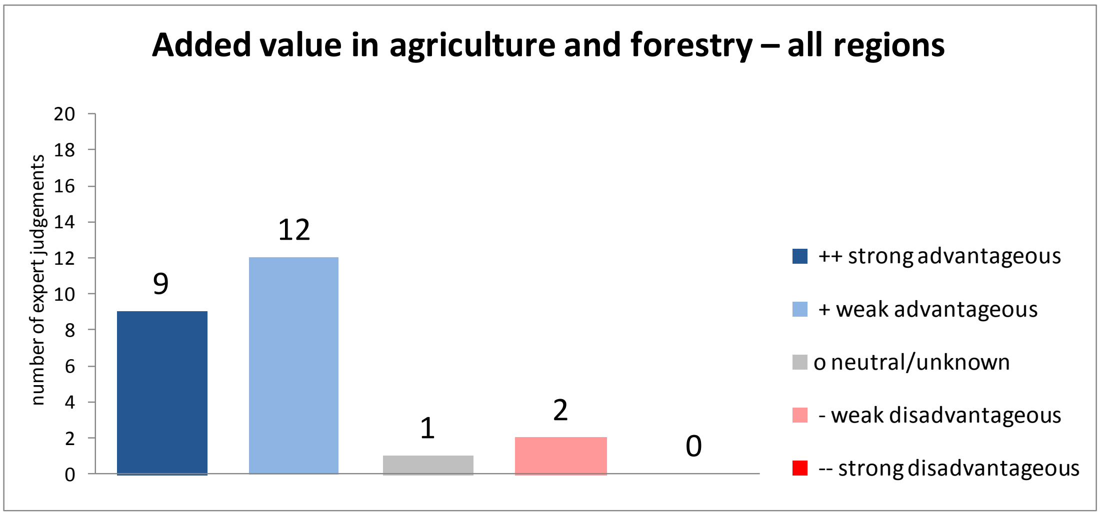
The sensitivity of a region towards policies affecting the pollution of soil and ground and surface water is measured by a proxy indicator taking into account the population density and the employment density. As this indicator is more responding to pollutants caused by urban developments than by agricultural 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

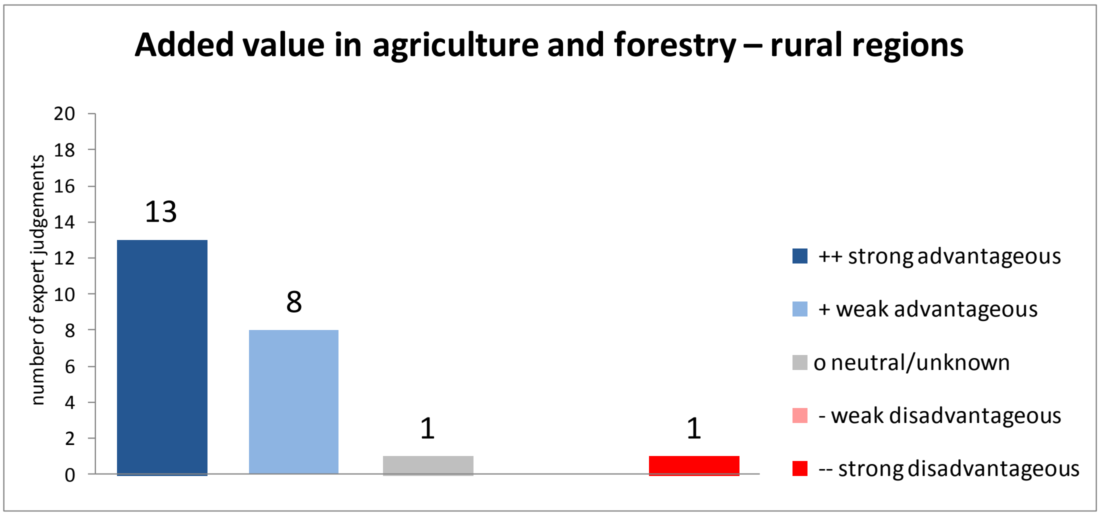
There was a clear agreement of the experts that the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge would definitely have a positive effect on the on the added value in agriculture and forestry. When looking at all regions, nine experts judged 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

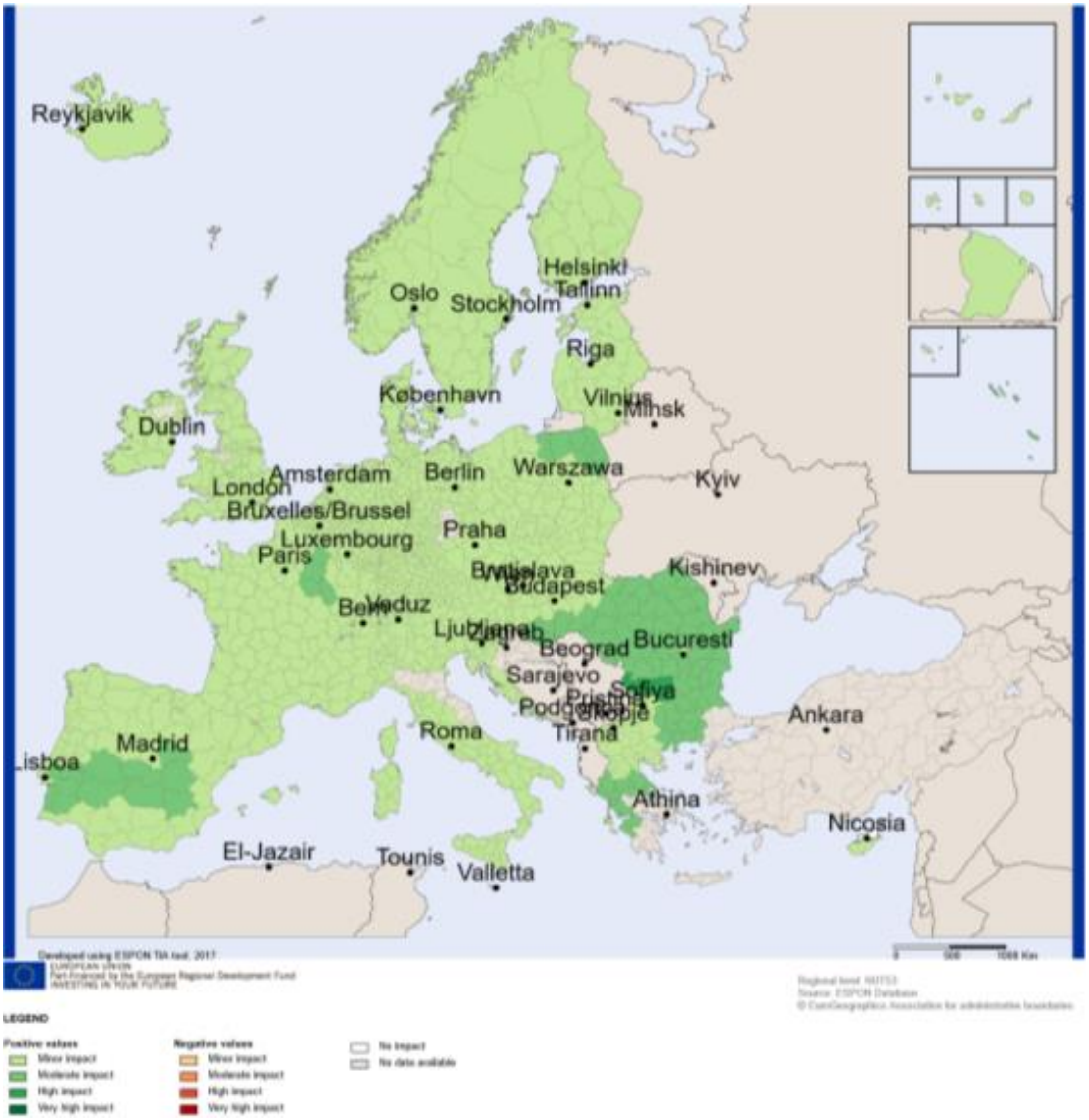
When focusing **on rural regions**, a majority of 13 experts judged the effects of this initiative as strongly advantageous, eight judged them as weakly advantageous and one judged them as strongly disadvantageous.

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.

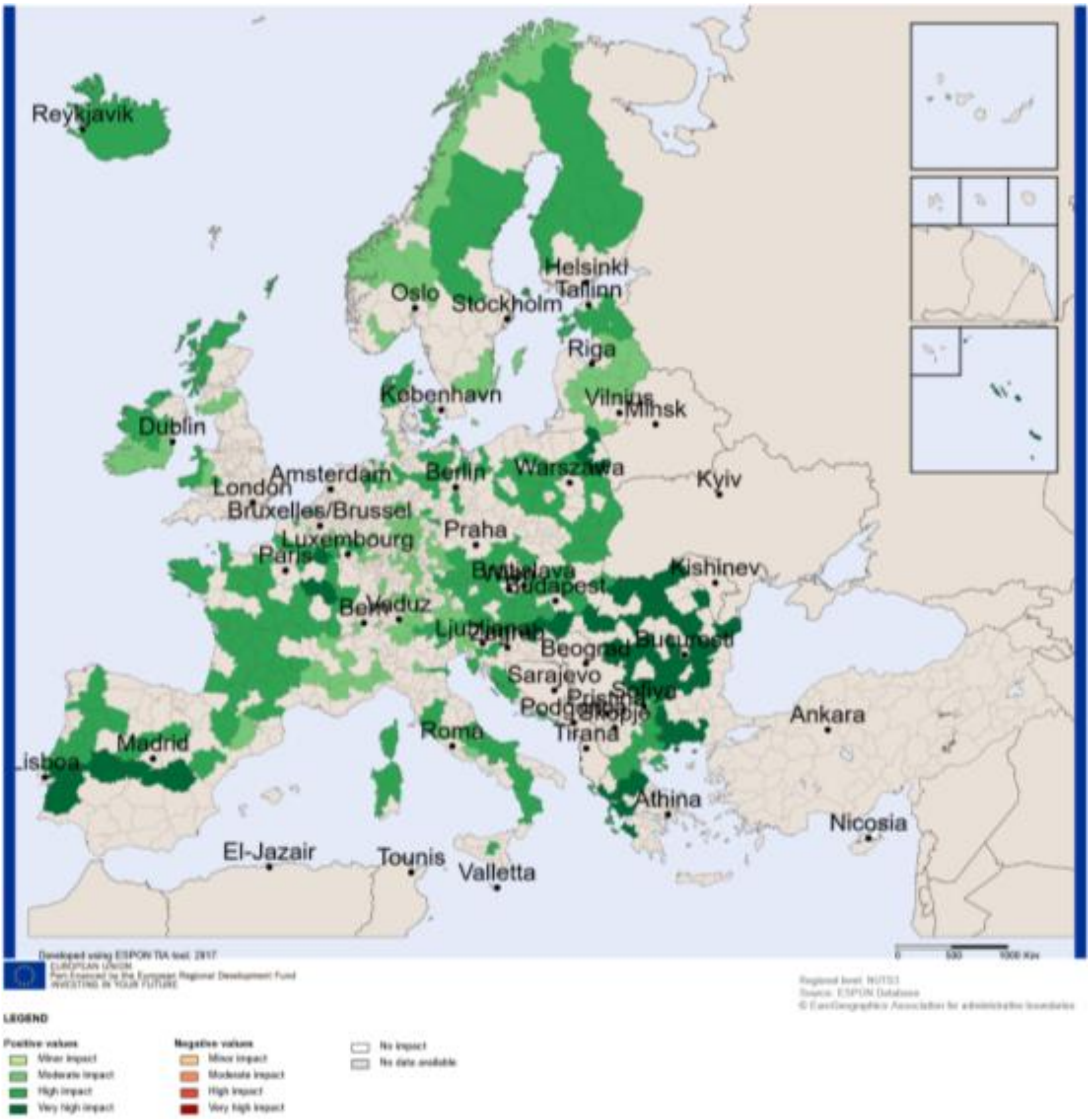
For rural regions the majority of the experts presumes a strongly advantageous effect. When they can use the new options for reusing sewage water rural regions with a high economic importance of agriculture rural regions could gain a very high positive impact as e.g. in Romania, Bulgaria, the North of 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



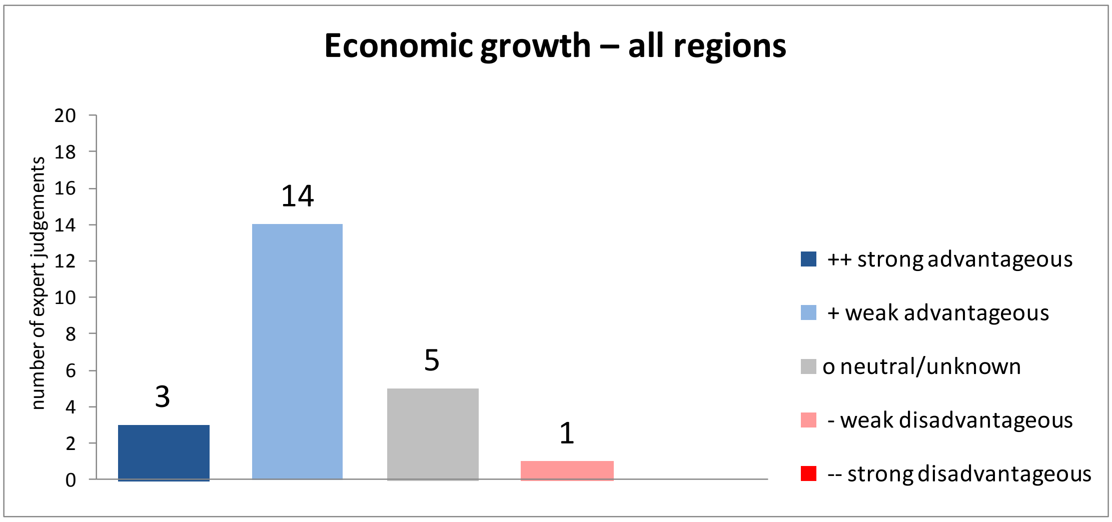
Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

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.

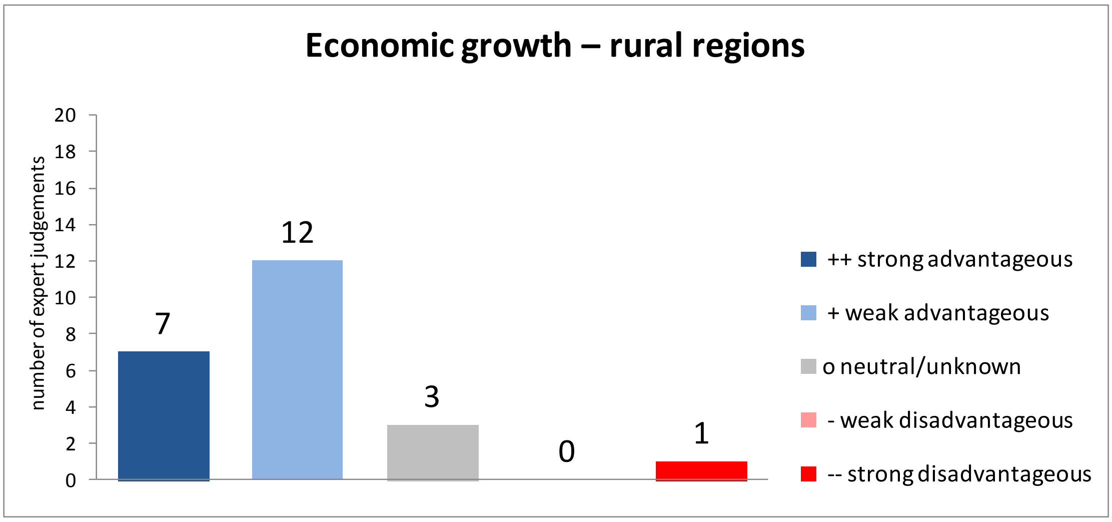
When focusing on rural regions the judgement was even more positive: In this case seven voted for a strongly advantageous effect and twelve for a weakly advantageous effect.

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>

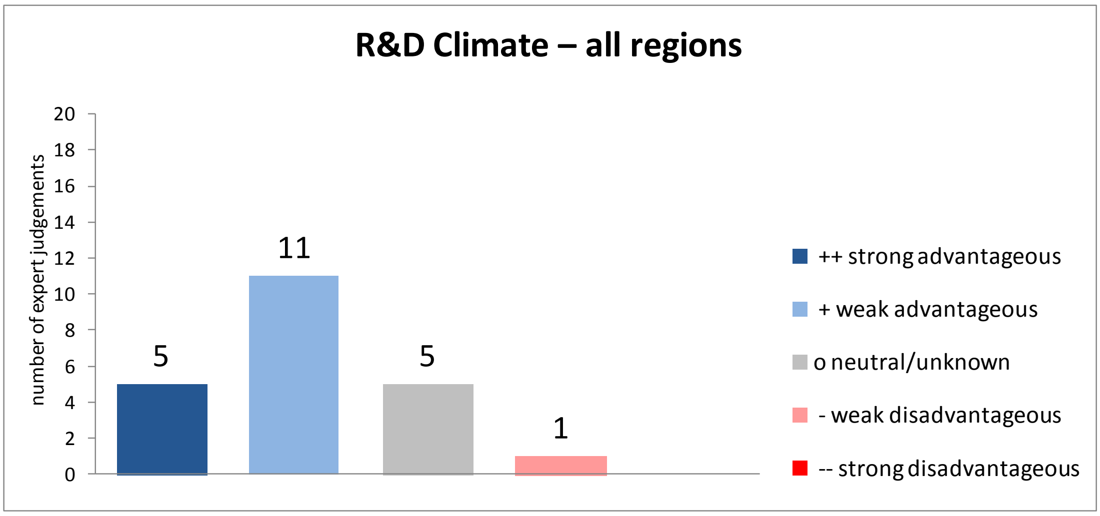
Map 4.3: Result of the expert judgement: Economic growth affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect

Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

4.3 The potential territorial impact based on the R&D Climate

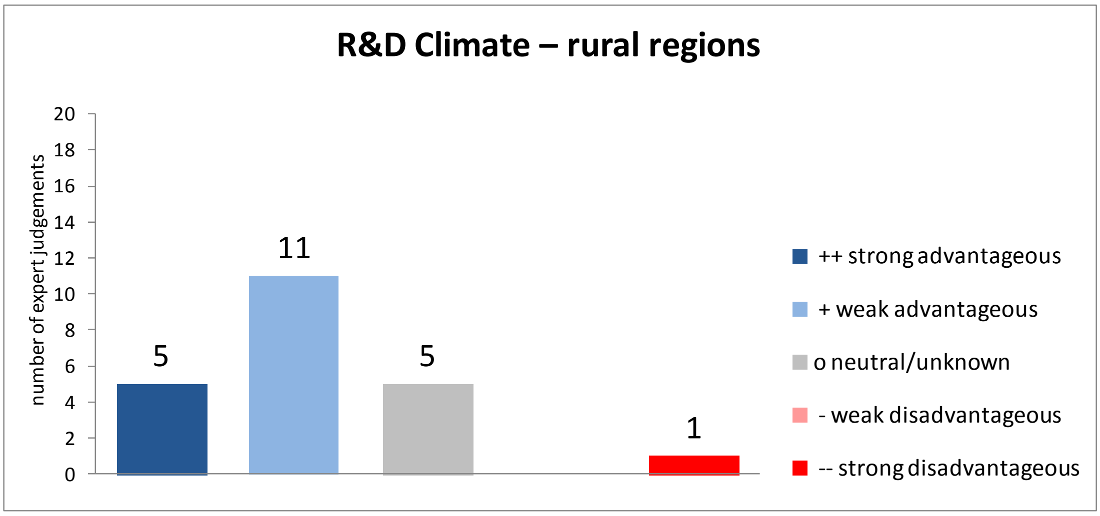
The experts assumed that new possibilities for using new technologies could arise in connection with the reuse of water in agricultural irrigation and aquifer recharge, which could stimulate the development of technologies in this field. Consequently, the experts saw an advantageous effect of the EU 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

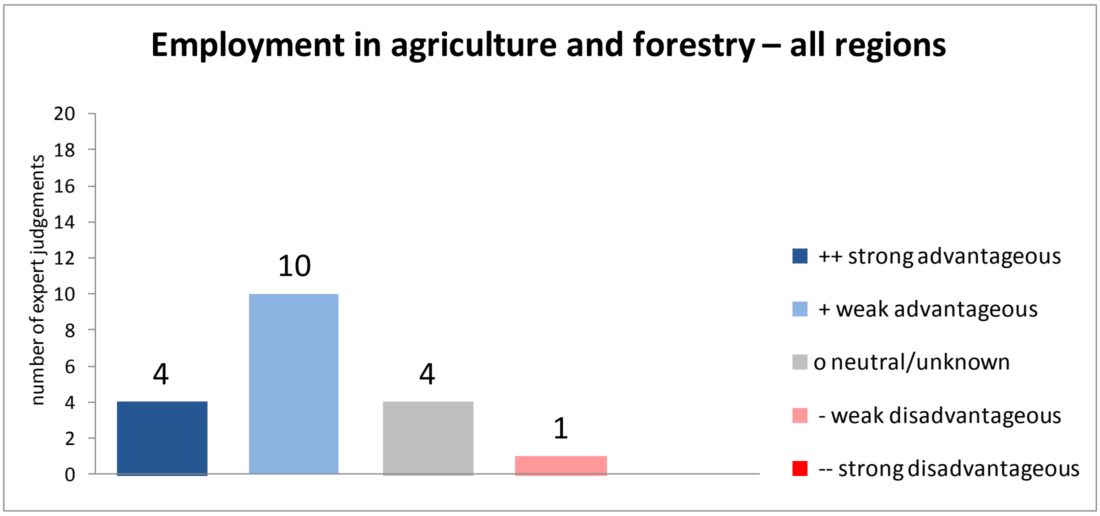
The sensitivity of regions related to the R&D climate is measured by the indicator "R&D expenditure". Regions with an already highly innovative climate and with a greater share of enterprises engaged in product and/or process innovation activities are considered to be more sensitive to EU initiatives 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

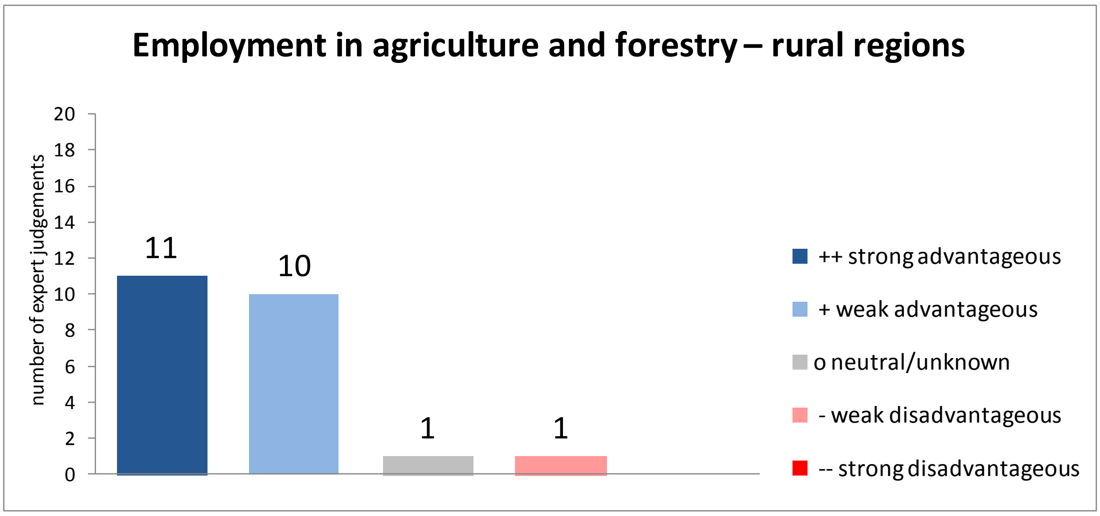


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

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.

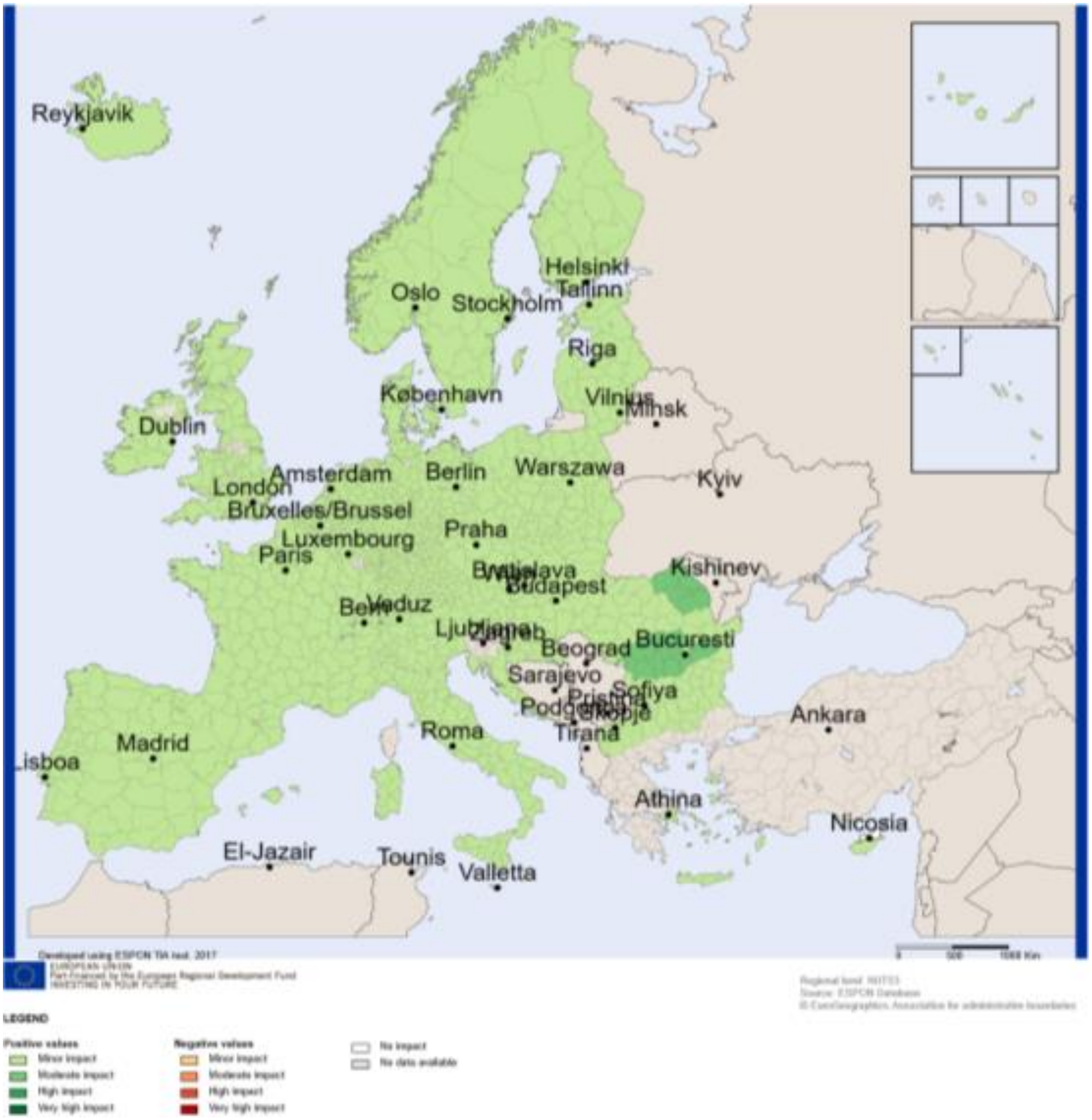


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

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.

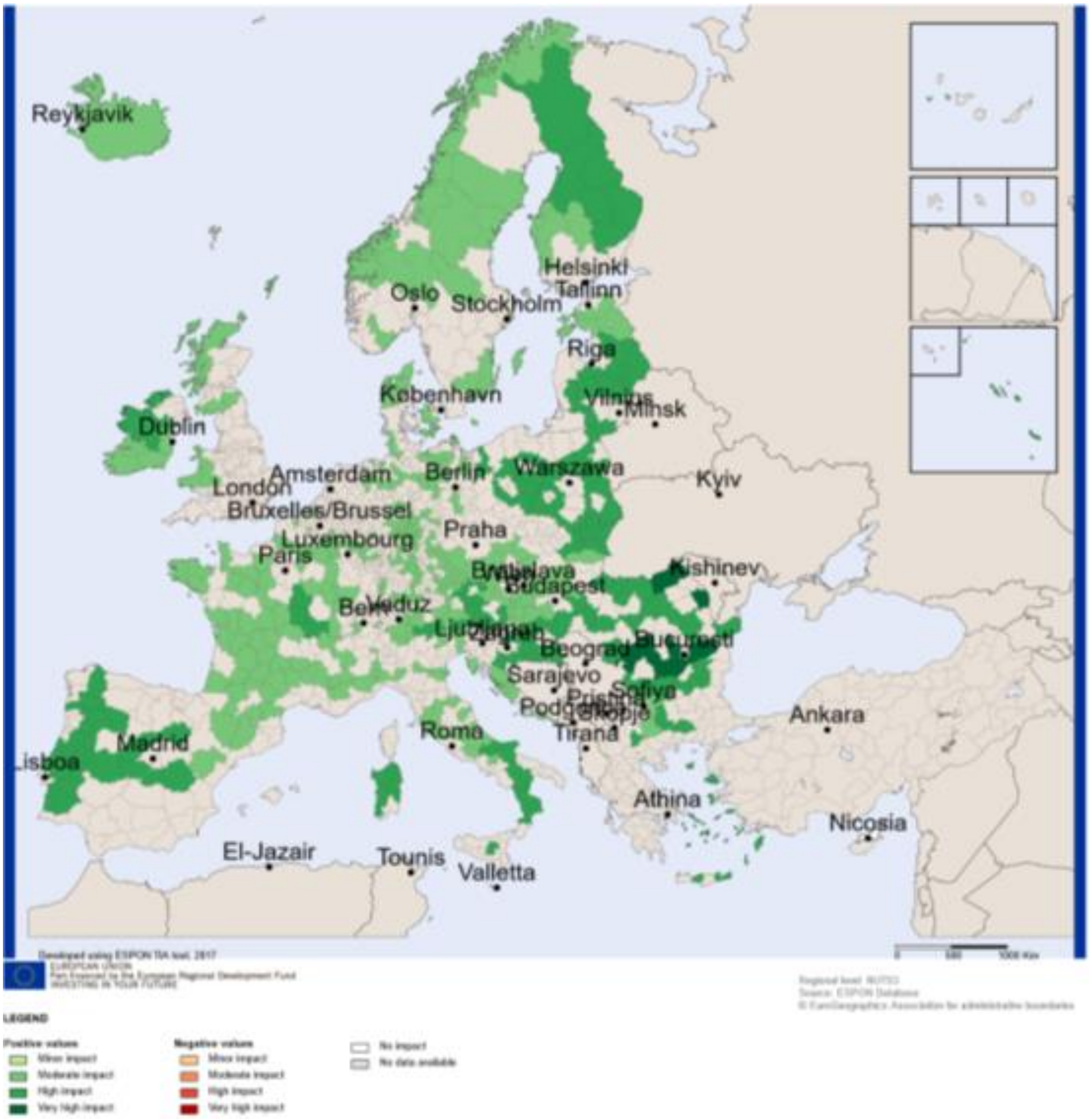
Map 5.1: Result of the expert judgement: Employment in agriculture and forestry affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect



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



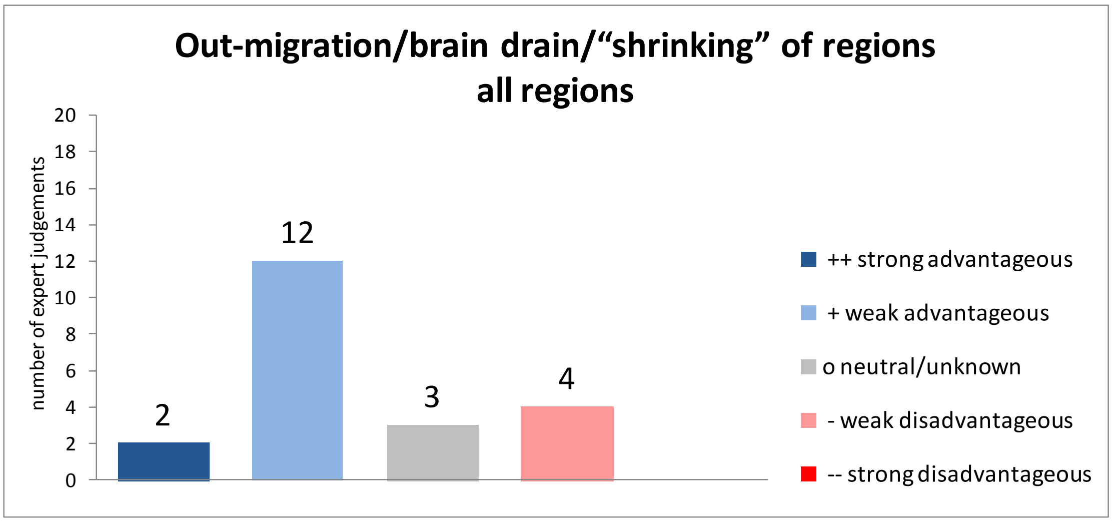
Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

Focusing on <u>rural regions</u> the majority of the experts voted for a <u>strongly advantageous effect</u>. 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, <u>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.</u>

5.2 The potential territorial impact based on out-migration/brain drain/"shrinking" of regions

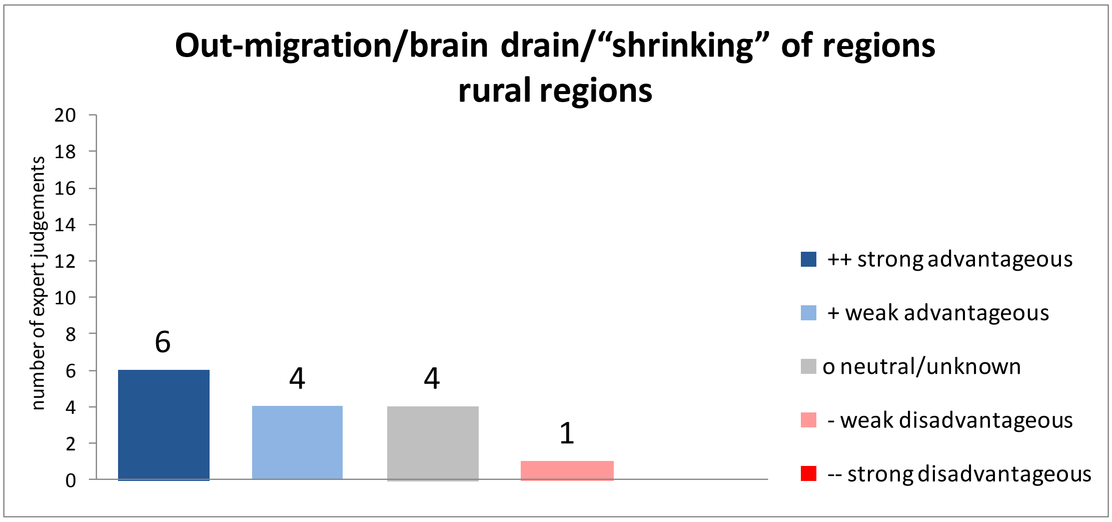
According to the experts' opinion the improved possibilities for agriculture and related employment possibilities in agriculture could reduce out-migration in currently shrinking regions. Twelve experts voted for a weakly advantageous effect in all regions and two experts voted even for a strongly advantageous 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

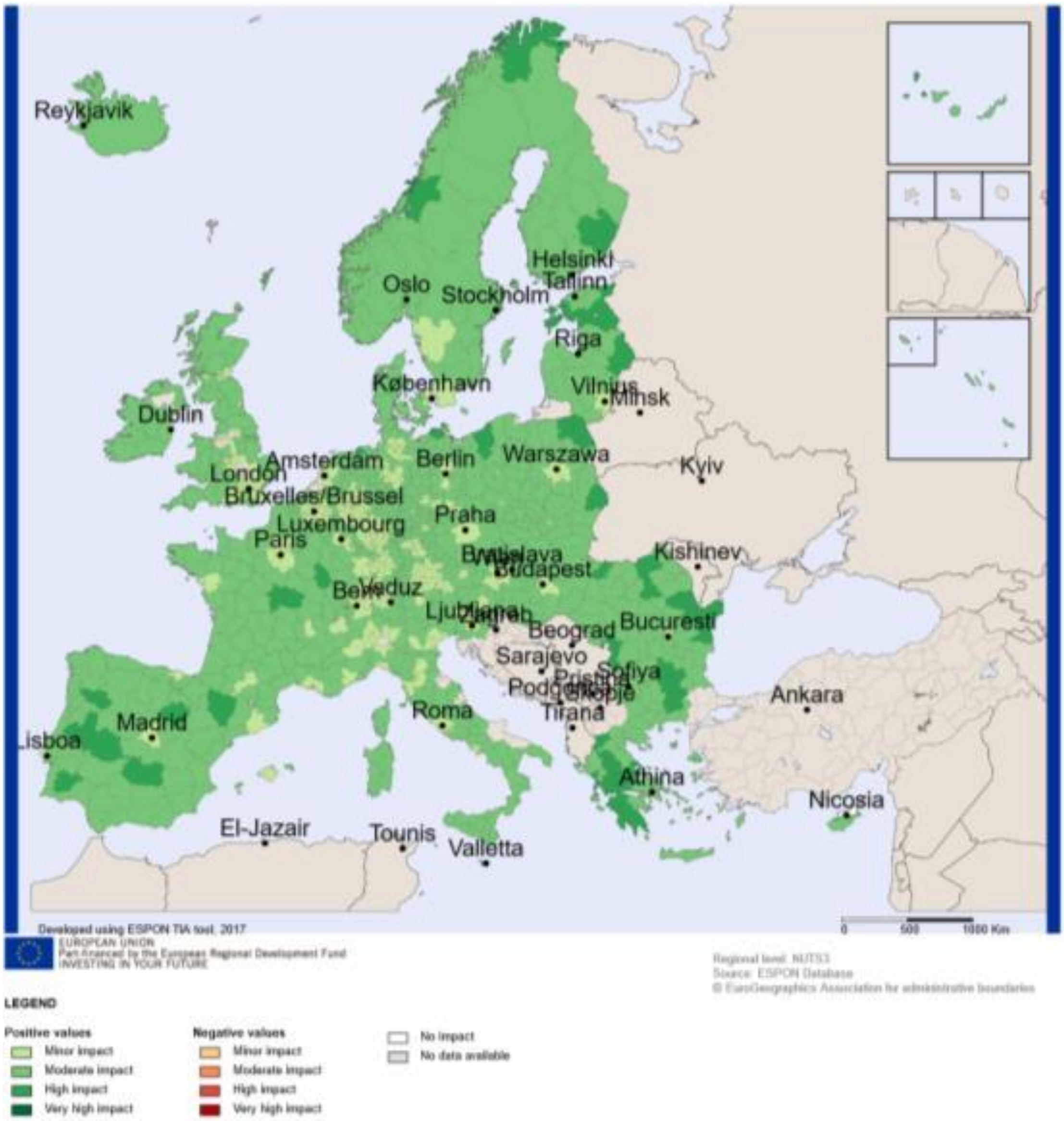


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

[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.

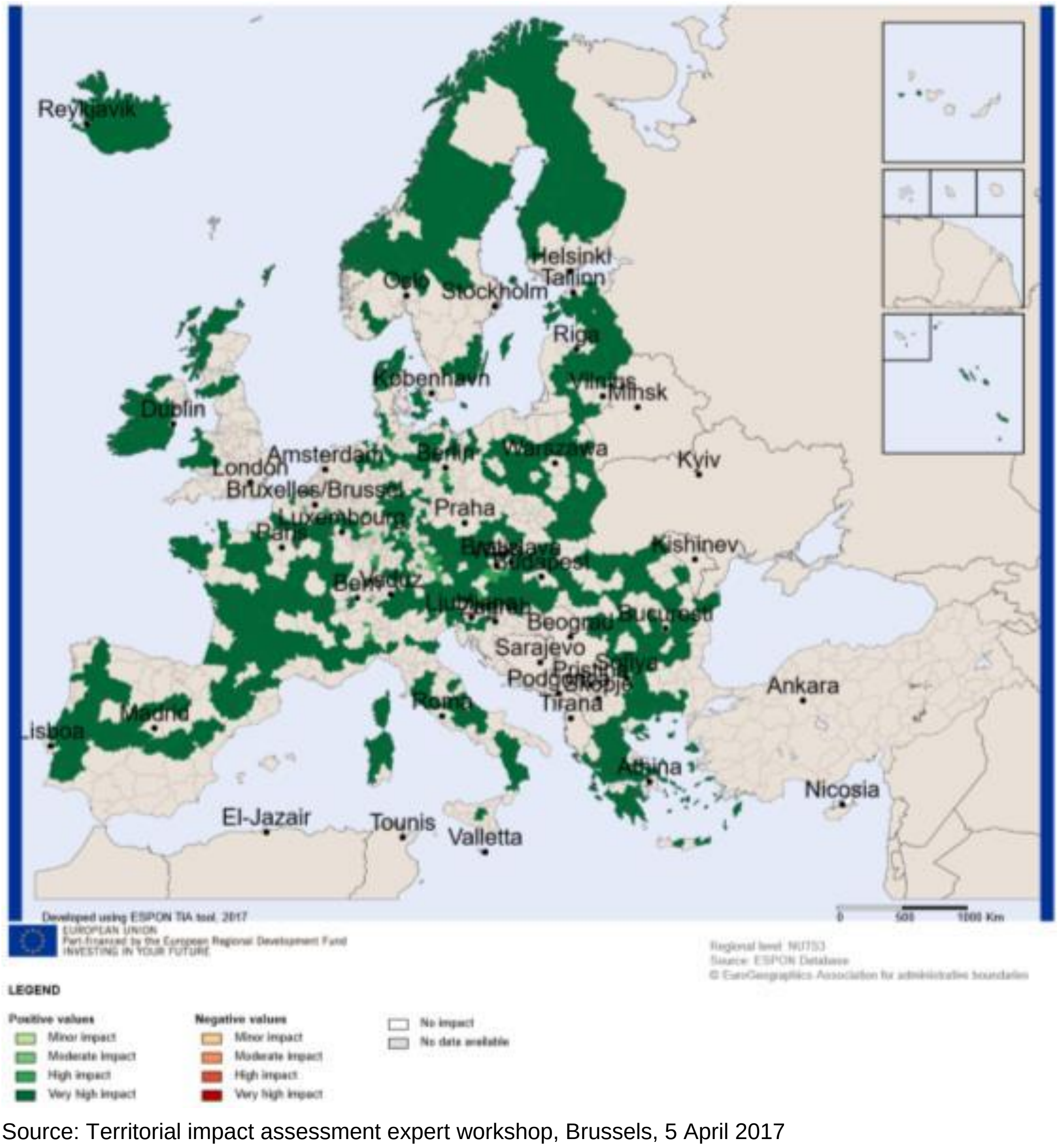
Map 5.3: Result of the expert judgement: Out-migration/brain drain/“shrinking” of regions affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect



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

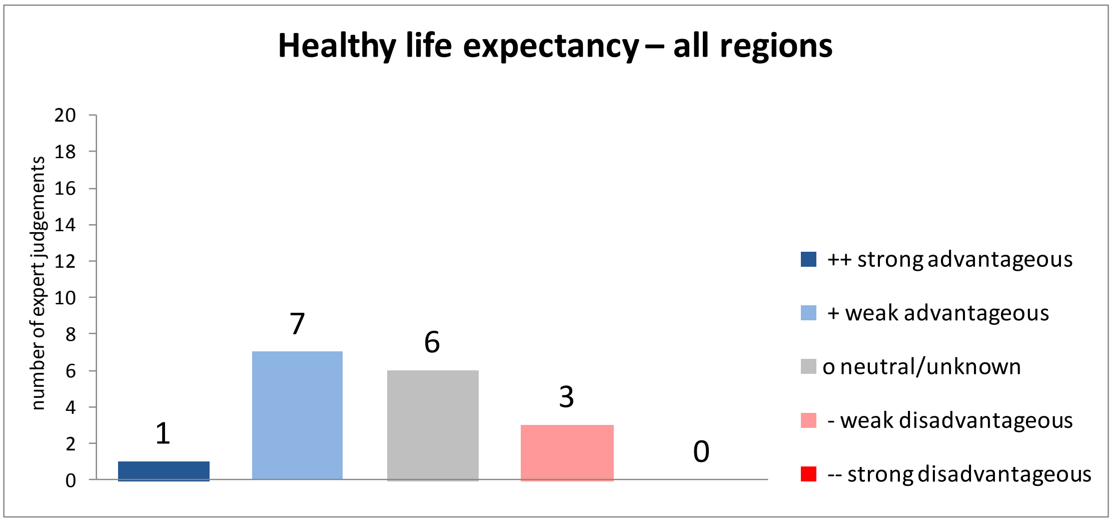


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

5.3 The potential territorial impact based on healthy life expectancy

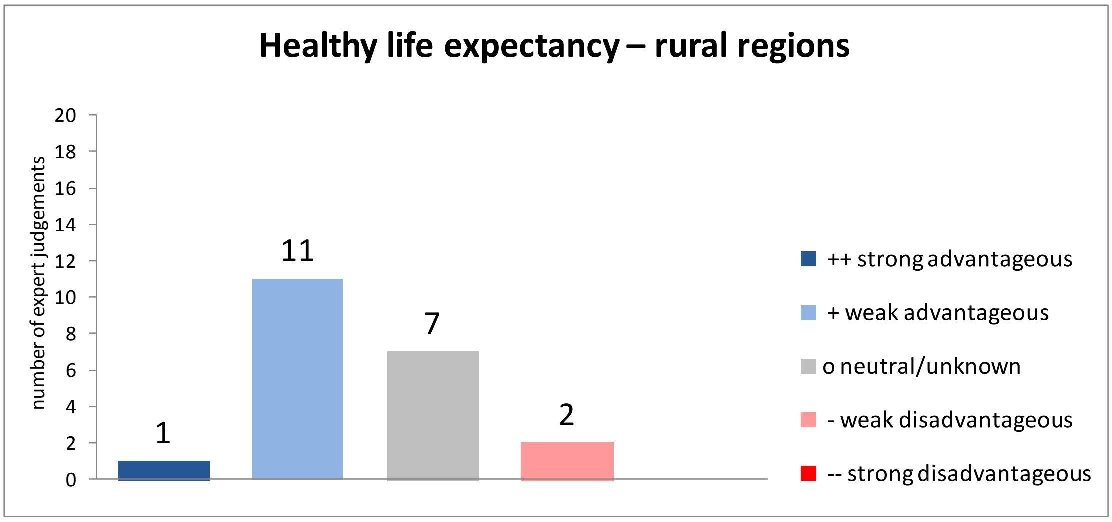
The majority of the participants saw a weak advantageous effect of the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge on the health of the population measured by the healthy life expectancy indicator. However, a minority was afraid that this 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

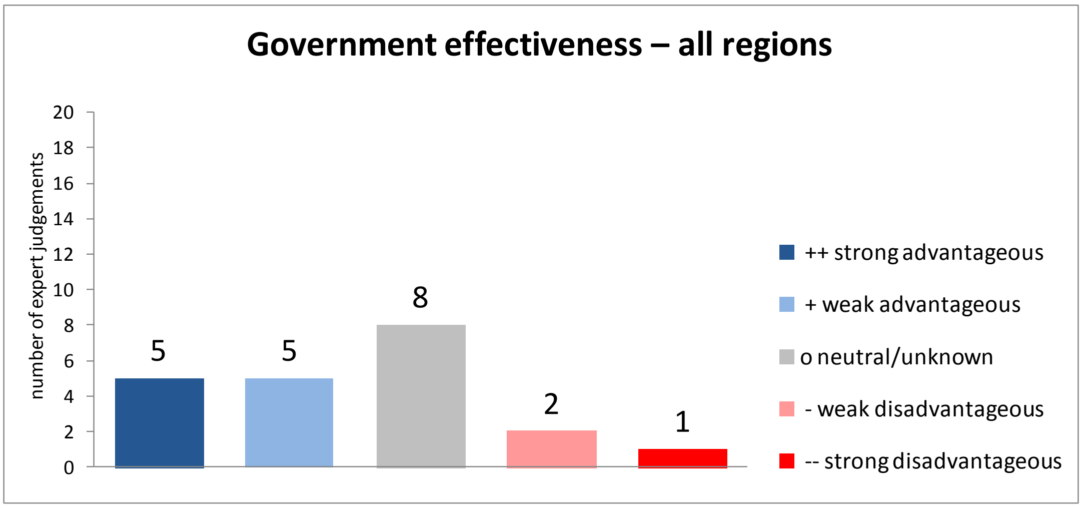
Regions in which the life expectancy is lower are expected to benefit more from policy measures effecting its increase and more negatively influenced by those which decrease it. This indicator was not considered as suitable by several experts, because they judged the cause-effect relation between the 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

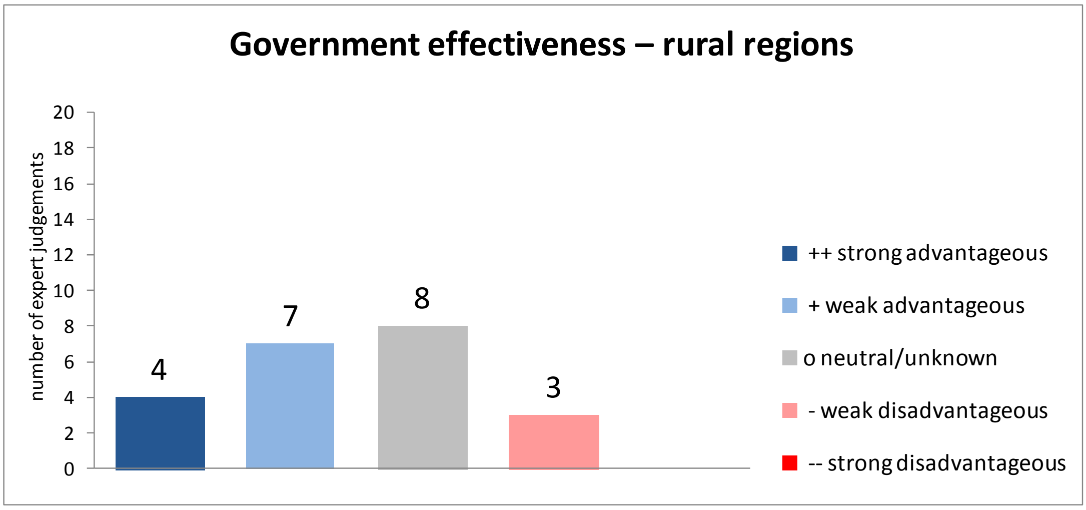
The experts considered that an efficient and correct implementation of the proposal to set minimum quality requirements for reused water in agricultural irrigation and aquifer recharge **could contribute to reduce administrative burdens**. However, if the implementation of the initiative is too complicated, 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

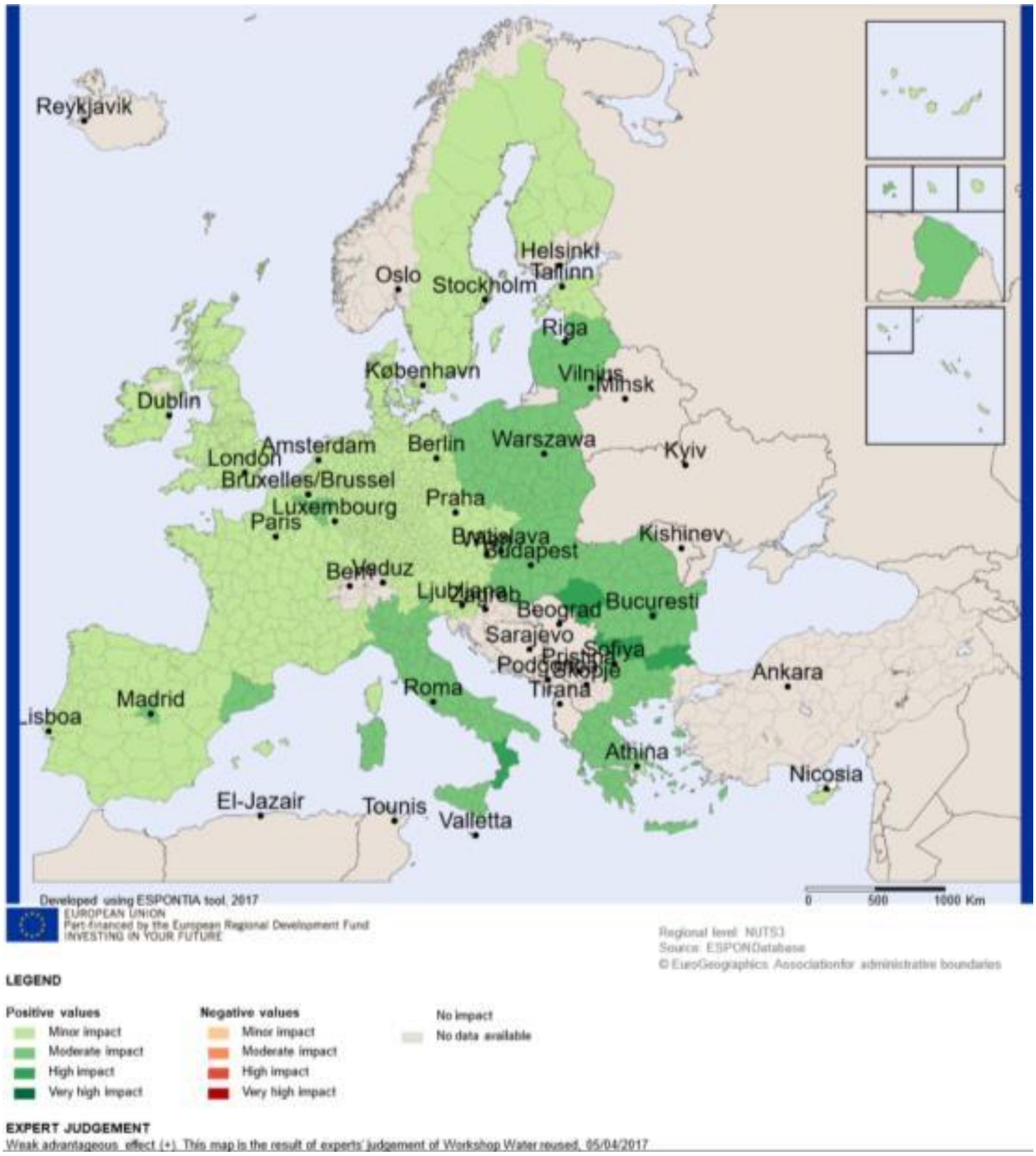


Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

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



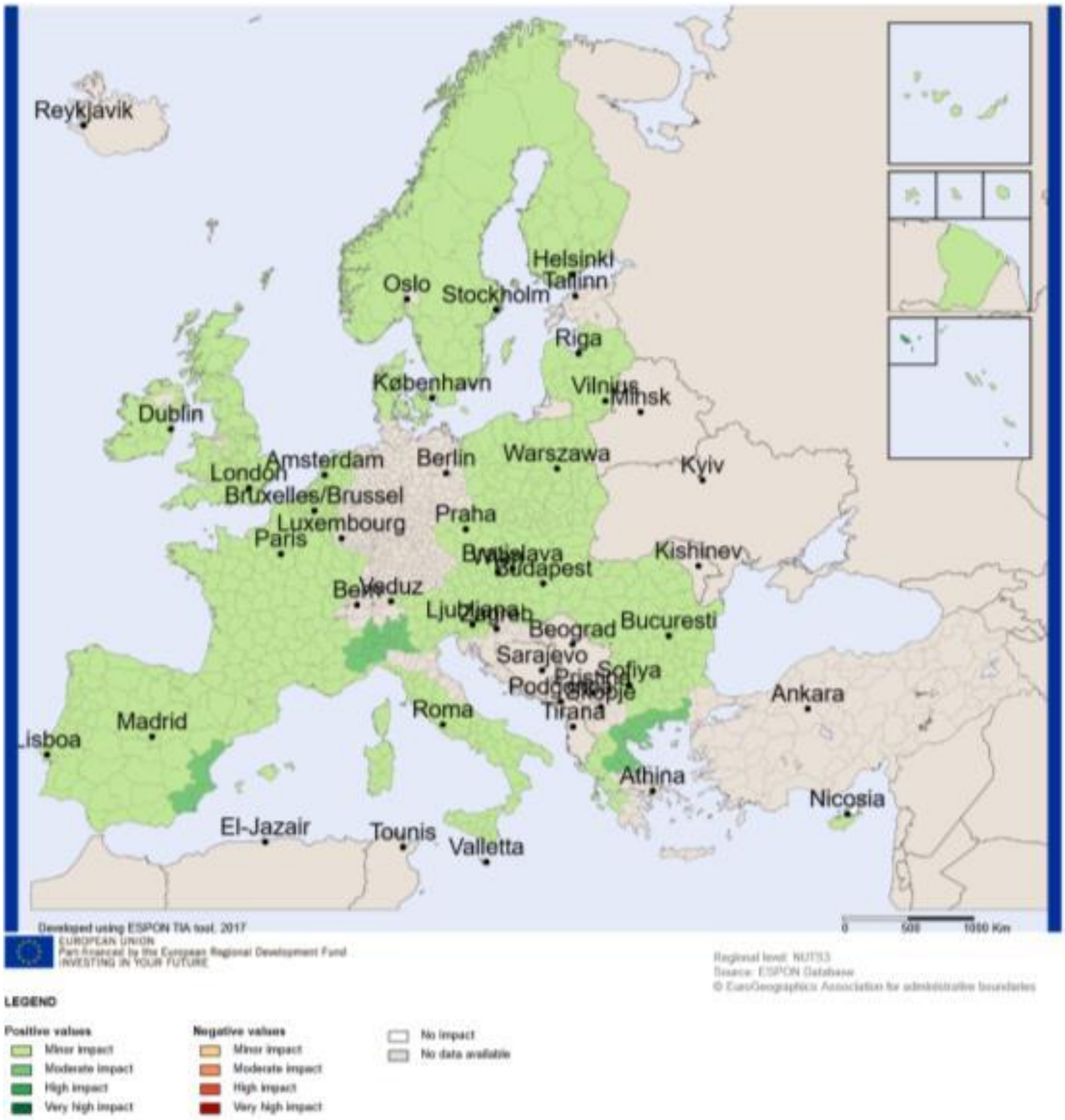
Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

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.

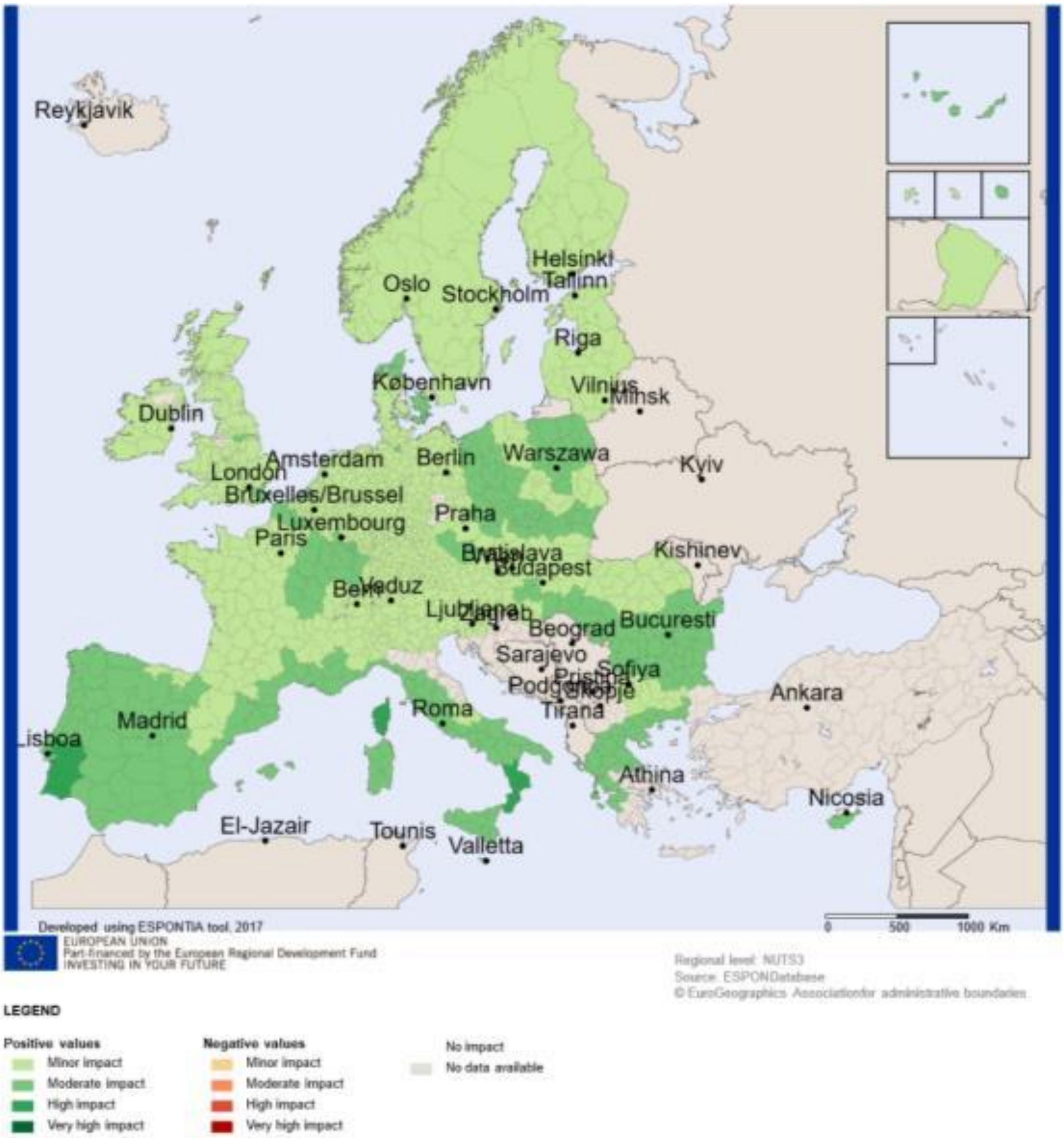
Map 7.1: Result of the expert judgement: Agriculture depending on irrigated land affected by the development of minimum quality requirements for reused water in agricultural irrigation and aquifer recharge – expert judgement: weak advantageous effect



Source: Territorial impact assessment expert workshop, Brussels, 5 April 2017

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. 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 **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.**

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.**

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.

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

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.

- 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.

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[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

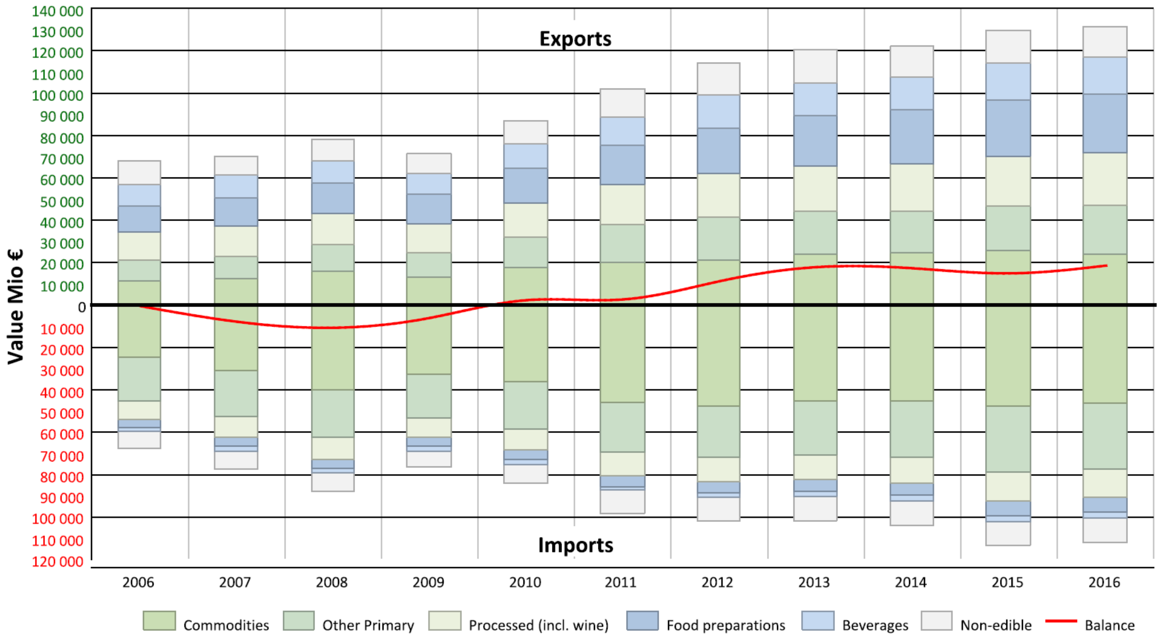
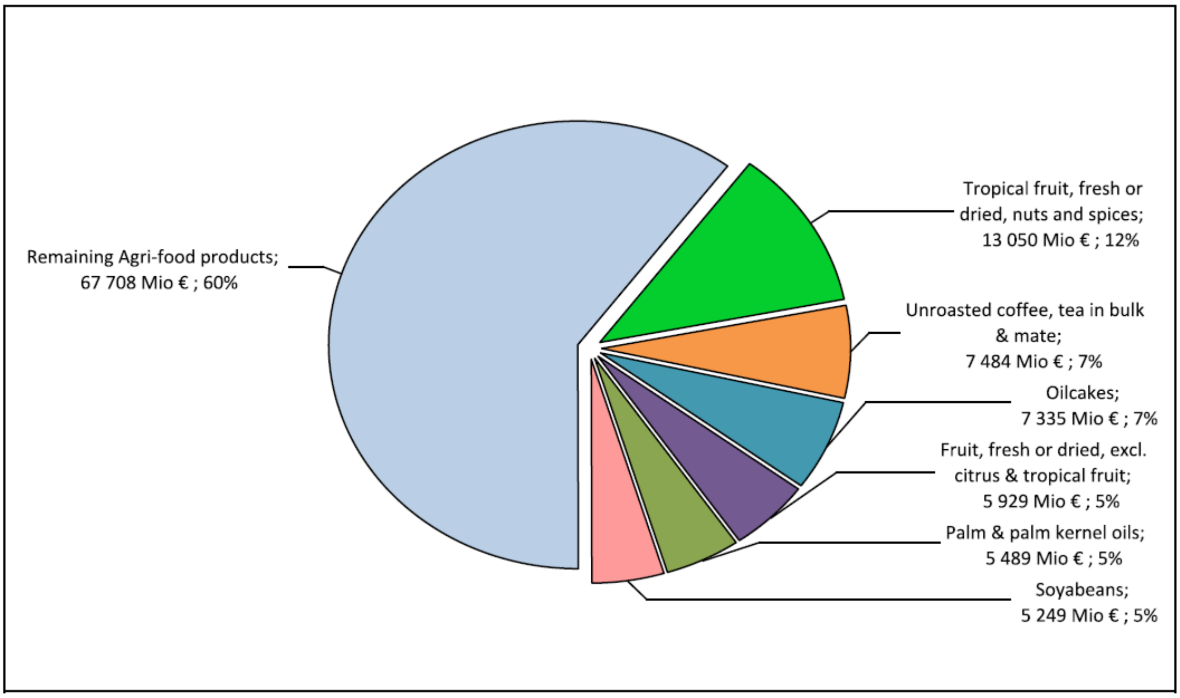


Figure 35: Top EU Agri-food imports from Extra EU 28 in 2016



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