SEVENTH FRAMEWORK PROGRAMME

THEME 6: Environment (including Climate Change)

Adaptive strategies to Mitigate the Impacts of Climate Change on European Freshwater Ecosystems

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Abstract

The REFRESH project aims to help design cost-effective adaptation and mitigation strategies for freshwaters to comply with the Water Framework (WFD) and Habitats Directives (HD). Task 6.5 is specifically concerned with flagging the wider benefits that mitigation actions to improve the water status generate. This report discusses the role that these wider benefits play in the economic analysis of these mitigation actions, notably in the analysis of disproportionality. A review of the existing scientific literature has proved that there is a significant and wide range of wider benefits associated with the implementation of measures to improve water quality, although evidence is skewed towards certain specific measures (e.g. buffers strips) while there is much less information on other. Most of the evidence is based on modelling approaches that are subject to some degree of uncertainty. Biodiversity, diffuse pollution, carbon storage, flow regulation and soil erosion control are the most notorious additional benefits identified in the literature. There is also evidence on the existence of less tangible benefits such education, cultural and amenity values.

A combination of expert consultation and stakeholder participation has been used in REFRESH to identify the wider benefits of measures to improve the water status in the six demonstration catchments of Work Package 6. Within this context, it was decided that in addition to what was promised in the project Description of Work (DoW) document, wider benefits would not be flagged "in isolation", but linked to the identification of cost-bearers and beneficiaries associated with the mitigation/adaptation measures under consideration. Hence, an additional task of these workshops was to identify these cost-bearers and beneficiaries.

Results indicate that identified costs and cost-bearers were mostly specific to the chosen mitigation measures and activities associated with them, while benefits and beneficiaries largely seem context-specific. Also, as probably expected, costs of protection measures are borne upstream and benefits are enjoyed downstream. Rather few anthropogenic sources of pressures exist, affecting the welfare of a rather large number of people.

Costs and cost-bearers identified and classified as important by local stakeholers include increased farm production costs and reduced yields, but also other sectors such as quarrying, fisheries and forestry. Water and drainage/sewage treatment authorities were also noted as significant cost-bearers in some catchments, while private households were expected to bear costs associated with septic tank management. Benefits and beneficiaries identified correspond to rather wider range than that associated with costs and cost-bearers. Recreational benefits were identified in all case studies and linked to economic welfare. Biodiversity benefits were also identified including those associated with species populations and wildlife health. Finally, an improvement of the quality of life was identified.

Regarding proportionality, it was argued that costs are more concrete and short term, while benefits were more abstract, subjective and longer term. In some cases this led to difficulties in the comparison of costs and benefits. However, there was a general opinion that benefits outweigh costs, despite their long term and "uncertain" nature.

In accordance to the objectives of Task 6.5, identified wider benefits were mostly non-water and non-strictly water ones. Main non-strictly water benefits identified for REFRESH demonstration catchments include biodiversity conservation, soil conservation, and increase of amenity and aesthetic values. Non-water benefits quoted include improvements in human health and wellbeing, gains in economic activity (including employment), educational resources and changes in attitudes towards environmental sustainability, and food security, but also pest control, climate change, retention of nutrients and organic material, air filtering, improvement of pollination, and generally, reduced environmental impacts.

We conclude that this exercise led to inference on the existence of a significant range of wider benefits associated with mitigation measures, which target the improvement of water quality. The existence of such benefits should play a fair role and be acknowledged in any holistic analysis of interventions to maintain water qualities to support sustainable and multifunctional management of European water catchments. Further, the link between these benefits and, rather complex factors such as perceptions on the state of the environment, development strategy capacity at the local level and economic factors influencing productive behavior should be taken into account when mitigation and adaptation actions are designed and implemented, in order to enhance policy efficacy. Finally, with the exception of the Louros case study, wider benefits identified in the context of Task 6.5 further support findings of Task 6.4 on the existence of proportionality and confirm that the chosen mitigation/adaptation measures would generate social benefits.

1. Introduction

Freshwaters provide society with goods that are very important to human well-being, such as clean water, food and energy. Also, freshwaters provide other services that are less tangible but equally important to humans. For example, they enable recreation and cultural inspiration for people. Moreover, the hydrological cycle contributes to flood protection, climate regulation and also supports wildlife (Acreman, 2001). All these benefits that freshwaters provide to humans are the so-called 'water ecosystem services' (Millennium Ecosystem Assessment, 2005). There are different types of ecosystem services, and different classifications exist (see Ojea et al., 2012 for a review of the different definitions and classifications of (water) ecosystem services). Broadly speaking, three main categories of ecosystem services can be distinguished[1]:

- Provisioning services: are the products obtained from ecosystems. For example: drinking water, commercial fishing and water for irrigation to produce food and energy.
- Regulating services: are the benefits related to the role that freshwaters have in nature. For example: climate regulation, flood regulation, water purification and wildlife support.
- Cultural services: are non-material benefits that people obtain from ecosystems. For example: recreation, aesthetic, symbolic and religious values.

The way nature works and delivers its services is complex, and often implies trade-offs. Changes in catchment management can lead to significant changes in hydrological functions, altering runoff processes from land to rivers, the frequency and severity of flood events, flood water storage, water availability and drought, the supply of sediment and nutrients, the dilution of pollutants groundwater recharge and water quality (Maltby and Ormerod, 2011). These processes in turn influence the provision of ecosystem services. Moreover, the ecosystem services provided by freshwater systems are threatened globally by climate change, drainage, burning, water extraction, eutrophication and pollution, overharvesting, invasion by exotic species, land conversion for agriculture and intensification of agricultural production (Millennium Ecosystem Assessment, 2005).

The REFRESH project aims to help design cost-effective adaptation and mitigation strategies to improve the ecological status of freshwater systems in compliance with the Water Framework (WFD) and Habitats Directives (HD). For this purpose, hydro-chemical and economic models have been applied, in combination with stakeholder consultation processes, to identify economically-efficient and socially acceptable sets of interventions to improve the ecological status of water bodies in six demonstration catchments across Europe – in the United Kingdom, Greece, the Czech Republic, Norway and Finland-. Due to the complex and

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[1]Definitions are based on the Common International Classification of Ecosystem Services by the European Environment Agency (2011): http://unstats.un.org/unsd/envaccounting/seeaLES/egm/Issue8a.pdf. The original Millennium Ecosystem Assessment classification (MA, 2005) also included supporting services. Since, supporting services have been placed to the intermediate ecosystem services group due to their indirect repercussion to human well-being (Wallace, 2007; Fu et al., 2011) and have been excluded from

interrelated nature of ecosystem functions and processes, interventions to comply with the WFD and Habitat Directive may also generate wider benefits in terms of their impact on other goods and services. For example, tree planting in buffer strips or shading of watercourses by tree planting may enhance biodiversity, enhance landscapes and sequester carbon. These wider benefits should be acknowledged in any holistic analysis of interventions to maintain water qualities to support sustainable and multifunctional management of European water catchments. Task 6.5 of this project, reported here, is concerned with the identification and discussion of these wider benefits in the six demonstrations catchments analysed in WP6. Within the context of this investigation, it was decided that in addition to the description of Task 6.5 in the project DoW document, wider benefits should be linked to the identification of cost-bearers and beneficiaries associated with the mitigation/adaptation measures under consideration. Hence, an additional task of these workshops reported here was to identify these cost-bearers and beneficiaries.

The work described in this report relates to other parts of the REFRESH project in the following ways:

- Analysis of disproportionality of the measures to improve the water status in the demonstration catchments (Skuras et al. 2011; Martin-Ortega and Skuras 2012; Martin-Ortega et al. 2013a; Balana et al. 2013; Martin Ortega et al. 2013b; Varjopuro et al. 2013b; Skuras et al. 2013; Vojáček et al. 2013; Skarbøvik et al. 2013).
- Stakeholder consultation processes on the social and economic effects of water quality improvements at the sub-catchment level (Martin-Ortega et al. 2012a and 2012b; Varjopuro et al. 2013a; Skuras and Psaltopoulos 2013; Slavíková et al. 2013; Holen and Skarbøvik, 2013).

This document is organized as follows. In the next section, the role of the wider benefits of mitigation actions is discussed in the context of the economic analysis of the WFD. Then, a review of the existing evidence of the wider benefits of measures to improve the status of freshwater systems is presented. In section 4, we present the general methodological approach followed in REFRESH for identifying these wider benefits in the demonstration catchments. This is followed by a synthetic presentation of main results across the REFRESH case study applications (Section 5). General conclusions are drawn in Section 6.

2. The role of wider benefits in the economic analysis of mitigation actions

The WFD allows the derogation of environmental objectives if meeting them has disproportionately high costs. This means, broadly speaking, that if the costs of the measures necessary to attain the good ecological status of water bodies prove to be higher than the benefits they provide, Member States are allowed to postpone deadlines for the achievement of the GES or set less stringent objectives (Martin-Ortega et al. 2013a).

From an economic efficiency perspective, cost-benefit analysis (CBA) is the tool for the assessment of disproportionality[2]. Traditionally in water management, CBA has focused only on market benefits. For example, improved biota and aquatic ecosystem health can result in increased fish populations, and subsequent market benefits for the fishing sector. However, a significant part of benefits generated by improved water-quality status corresponds to ecosystem goods or services that are not traded in existing markets (Birol et al. 2006, Brouwer et al. 2008). Indicatively, increased water quality contributes to healthy habitats and enhanced biodiversity, valued by society for their scenic beauty and recreational potential, as well as other cultural and non-use values (UK NEA 2011). Moreover, increased water quality also has positive effects on human health and the availability of drinking water. A CBA which does not consider other less tangible ecosystem services can result in an underestimation of benefits and may bring about a decision of not undertaking action due to disproportionality of costs. This could lead to a sub-optimal decision for society.

Martin-Ortega et al. (2013a) discuss what benefits should be included in the comparison with costs the analysis of disproportionality of the WFD. These include: market and non-market benefits from increased water quality, benefits from reduced contemporaneous and inter-temporal costs, as well as associated non-water environmental benefits (Table 1). The latter correspond to the notion of 'wider benefits' as applied in the REFRESH Project. These wider benefits are to be considered as additional benefits provided by measures to improve water quality and have been largely ignored until now in the literature on the economic analysis of the WFD (see Martin-Ortega et al. 2013a for a review[3]). This is not surprising, since the quantification of the range of services provided by ecosystems and the accurate estimation of its associated values is one of the most challenging tasks that environmental economists are currently facing (MA 2005, Fisher et al. 2009, UK NEA 2011). It cannot be expected that disproportionality analysis in the context of the WFD can deal with such issues in the time frame required from compliance. It is therefore not reasonable to expect a quantification of the wider benefits that water quality improvement can provide for its inclusion on any cost–-benefit analysis. However, when these benefits can be expected to be significant, they should be acknowledged and used in the final interpretation of the CBA results.

[2]As discussed in the REFRESH discussion paper *Assessing proportionality/disproportionality of compliance costs: Conceptual issues, methods, applications* (Skuras et al. 2010) and the subsequent *Methodological Approach to Disproportionality Analysis* agreed in WP6 (Martin-Ortega and Skuras, 2012), in the REFRESH project, the economic efficiency criteria implicit in CBA is not the only criteria for consideration in the analysis of disproportionality. Distributional effects and affordability considerations have also been considered in the economic analysis of measures to improve the water status in the REFRESH demonstration catchments.

[3]An exception in the literature reviewed by Martin-Ortega et al. (2013) is the study of Meyerhoffl and Denhardt (2007), who do include a discussion in relation to the multiple benefits provided by wetlands.

This is the approach that has been taken in the REFRESH project (*Methodological Approach to Disproportionality Analysis* agreed in WP6; Martin-Ortega and Skuras, 2012); in which expert and stakeholder consultation processes have been applied to identify the range of wider benefits potentially generated by mitigation actions to improve the water ecological status in the demonstration catchments (see Section 4 of this document for the details on the methodological approach). The extent and importance of these wider benefits can be used to discuss economic efficiency indicators, such as the Net Present Value (NPV). For example, CBA resulting in a NPV close to zero in a context were significant wider benefits are expected, can be used as indicator of the social desirability of the mitigation programme (i.e. the costs of the measures might just be somewhat larger than the direct benefits derived from them, but if the wider benefits were accounted for, the results would have been reversed).

Table 1. Types of benefits to include in the analysis of disproportionality of the WFD

Type of benefits	Definition
Market benefits from increased water quality	Commercial benefits that may increase due to water quality improvement or generated by some measures.
Non-market benefits from increased water quality	Welfare gain resulting from the improvement of water quality from the current to GES (Brouwer et al. 2009).
Associated non-water environmental benefits	Benefits beyond the water-related ones, i.e. wider benefits in terms of their impact on other ecosystem goods and services.
Benefits from reduced contemporaneous costs	Benefits from reducing the opportunity costs imposed by the water's current use.
Benefits from reduced intertemporal costs	Benefits from reducing the opportunity costs imposed by using the water today and due to over-abstraction deprive future users desiring to abstract the demanded quantities.

Source: Martin-Ortega et al. (2013)

3. Review of the existing evidence of the wider benefits of measures to improve water quality

3.1 Methodological approach to the review

In this section a review of existing evidence of the wider benefits generated by measures to improve the status of freshwater systems is presented. The relevant scientific literature was identified via computerized searches, using the terms (in English) 'water', 'ecosystem service(s)', 'ecosystem benefit(s)', 'freshwater benefit(s)', 'water service(s)', "water quality", "ecological status". Abstracts of articles and reports identified using these keywords were reviewed, and apparently appropriate articles were examined in their entirety. Reference lists were scanned for other relevant articles. Eighteen relevant articles were finally used to construct a review table (see the Annex), which is used here as the basis for discussion. It should be noted that this is not intended as an inventory of all the existing literature, but rather to provide a broad overview of the existing evidence.

It is not always straightforward to distinguish between benefits which are strictly restricted to the water environment and the so-called wider benefits. For this reason, on our review we had made a distinction between: i) strictly water benefits, ii) non-water benefits and iii) non-strictly water benefits. An example can serve to illustrate the differences between the three categories: see Box 1 for an example in relation to the benefits generated by buffer strips along water margins.

Box 1. Different types of benefits generated by the implementation of buffer strips.

Strictly water benefits: Are those benefits strictly related with the water condition. For example, the runoff water from the fields is polluted and when it passes through the buffer strip, the roots and the soil structure in the buffer area retain most of dissolved diffuse particles (P, N, herbicides) that are then removed from the water. The improvements of the water quality contribute providing water supply (e.g. drinking water) and aquatic wildlife habitats (e.g. fish recruitment and increment of fishing).

Non-water benefits: Are those benefits that are not strictly related to the water environment. For example, the vegetation and the soil in buffer strips capture atmospheric CO_2, the trees provide timber and the roots stabilize the soil structure and avoid soil losses.

Non-strictly water benefits: Are those benefits at the frontier between strictly water benefits and non-water benefits. For example, the vegetation in buffer strips provides amenity and wellbeing for the local people and the visitors who enjoy the view. The improvement of water quality provides more recreation option as swimming, sailing, picnicking, and hiking.

The Annex shows a compilation of the relevant literature. For each of the reviewed studies, the Table presents:

- The mitigation measure at stake, for example, implementation of buffer strips along water margins or constructed wetlands. Some studies refer to a combination of measures. In a number of studies it is not possible to identify specific measures, and benefits are referred to the general improvement of the water status.
- Study zone: It is important know where the measures are implemented and the biophysical conditions that characterize the area. This could be useful for transferring the evidence to other places with similar characteristics.
- Context: includes a description of the human and bio-physical context of the study, including the current land use and the environmental threat to which mitigation actions are responding to.
- Benefits provided by the mitigation measures. As explained above, these are categorized in: Strictly water benefits, Non-strictly water benefits and Non-water benefits.
- Research approach: The methodology used on the research is identified for each of the studies analysed. We distinguish five main general approaches: i) experimentation, ii) modelling, iii) expert judgment, vi) stakeholder

judgment, and v) review. Table 2 briefly describes what is meant by each of these approaches.

- Limitations and uncertainty: Since this review is aimed at identifying the existing evidence, it has been considered appropriate to highlight the limitations and reported uncertainty of the studies in order to set the evidence's boundaries.
- Monetary benefits: For those cases in which a monetary assessment of the benefits has been made, this is also reported.

Table 2 Research approaches used in the literature to identify/assess benefits of measures to improve the water status

Approach	Description
Experimental	Based on systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses
Modelling	Based on the use of different modelling approaches and simulation
Expert Judgement	Consultation to specialists by expert panel and surveys
Review	Meta-studies of relevant literature
Stakeholder Judgement	Based on stakeholder view and knowledge by survey and workshop

3.2 Main results for the literature review

Details of this review are presented in the Annex of the report. Here we summarize the key findings.

Geographical extent

Evidence on the water and wider benefits of measures to improve the status of water systems is well spread across the world. We have found evidence from Europe (Borin et al., 2010; Evard et al., 2012; Garmedia et al., 2012; Willaarts et al., 2012; Jansson and Nohrstedt, 2001; Guimarães et al., 2012; Babatunde et al., 2008), Asia (Guo et al., 2000; Bai et al., 2011), Australia (Towsend et al., 2012; Crossman et al., 2010), Africa (Le Maitre et al., 2007) and America (Qiu and Dosskey, 2012; Sahu and Gu, 2009; Loomis et al., 2000; Yang et al., 2011;

Bednarek, 2001). This proves that the concern about water quality worsening has motivated mitigation measures research all around the world.

Mitigation measures

A wide range of mitigation measures have been studied. However, research is skewed towards some of them. Most studies are focused on the effects of buffer strips and benefits of this measure have been studied in depth (Borin et al., 2013; Qiu and Dosskey, 2012; Sagy and Gu., 2009; Le Maitre et al., 2007). Similarly, reforestation, re-vegetation and changes in agricultural practices have also received significant attention in the literature, but they are usually implemented and researched in combination with other measures. They have received particular attention in arid or semi-arid places (Australia, Africa and the Mediterranean area) where the main problems are related with high levels of salinity, pollutants from the agricultural products, reduction of water supply and land degradation. The measure has also been implemented with other aims: to reduce the coal mining impact (Bai et al., 2011), to improve hydroelectricity efficiency (China) (Guo et al., 2000); and to increase CO_2 accumulation (Sweden) (Jansson and Nohrstedt, 2001).

Types of benefits

As explained, this review has distinguished between three different types of benefits: strictly water quality benefits (such as reduction of water pollutants); non-water benefits (such as carbon sinks and timber production) and non-strictly water benefits (such amenity and recreation) (Table 3).

Key observations in relation to these benefits are:

- Unsurprisingly, strictly water quality benefits are the ones most often reported. This is to be expected, since the literature search was driven by looking at measures to improve water quality. The most frequently studied benefits are those related to basic human needs, such as availability of consumptive water or flood control (to avoid the damage in fields and urban infrastructure). Other benefits include market benefits, such as hydropower production and market benefits associated with angling. Other benefits relate to reduction of damage to waterways by siltation and retention of nutrients in wetlands.

- The non-water benefits are many and diverse. These include provisioning services, such us wood production and improvement of agricultural production, regulating services, such as carbon storage, erosion control and nutrient cycling.

- The non-strictly water benefits in general relate to non-consumptive benefits. The most looked at benefit in the studies is biodiversity conservation. Other benefits include recreation and tourism as well as less tangible benefits such as amenity and aesthetic values.

Table 3. Types of benefits identified in the literature

Type of benefit	Benefits
Strictly water benefit	• Control of diffuse pollution • Flow regulation • Flood regulation • Water supply • Reduction of damage to waterways by siltation • Reduction salt solute in water • Retention of nutrients in the wetland • Improvement in Hydroelectricity production • Angling • Hydrological buffering • Prevention of foreign species of plant and algae • Reduction of eutrophication • Reduce vulnerability to waterlogging • Dilution of wastewater • Fish recruitment
Non-Strictly Water Benefits	• Recreation • Biodiversity conservation • Optimization of soil nutrient cycles • Amenity value • Aesthetic value • Tourism • Hunting • Bequest and existence value • Cultural value
Non-Water Benefits	• Green corridor (reduced landscape fragmentation) • Employment opportunities • Meso-climate regulation • Retention of nutrients and organic material • Protection of infrastructures • Noise reduction • Air filtering • Improvement of human health • Reduction of poverty • Improvement of Pollination • Reduced environmental impacts • Food security • Pests control • Restoration estuary and costal and habitats and biota • Educational resources

The classification of benefits used in this review requires further discussion. The benefits are not necessarily of the same nature: some of them are related to an ecosystem process or functions (e.g. nutrient cycling) and others are final services (e.g. water supply). The distinction between processes, intermediary services, final services and benefits is still under discussion in the literature (see Fisher et al. 2009). Here we refer to the types of services that are actually reported in the studies and we classify them according to the purposes of our review (i.e. whether they benefits strictly related to water quality improvements or they are wider benefits and therefore are likely to be included in cost-benefit analysis of the WFD).

It should be noted that the benefits of water quality improvements are often not explicitly associated with specific measures but rather with the improved status of the freshwater system such conservation of biodiversity, increment of the ecosystem resilience or reduction of environmental impact. In other words the general improvement of the aquatic ecosystem is associated with an increment of ecosystem services and benefits provision.

Research approach

Different methodological approaches to study the benefits of water quality improvements are used in the literature. Most of the reviewed articles use modelling approaches to predict the results of the measures before implementation. This allows comparing the efficiency of different measures in different scenarios, but since they represent a simplification of reality they are limited in their capacity of representing complex hydrological processes. Some of the models used in the literature reviewed here include: The Soil and Water Assessment Tool (SWAT) (Sahu and Gu, 2009, Yang et al., 2011), the hydrological model LUCICAT (Townsend et al. 2012), Tree model (Crossman et al. 2010), Model BalanceMED (Willaarts et al., 2012), hydrologic model Kineros and GIS AGWA tool (Nedkov and Burkhard, 2012), and the Systems Approach Framework (SAF) (Guimarães et al., 2012).

Other studies take an experimental approach (Garmedia et al., 2012; Qui and Dosskey, 2012; Evard et al., 2012; Borin et al., 2010). Experiments have the advantage over models in that they reproduce real natural ecological conditions, but they have their own limitations. They not always allow replications and results can be different in different areas because of the different conditions. These methods often require long time and significant resources to produce appropriate results.

The stakeholders and expert consultation, using surveys and workshops' discussions, is also used for the identification of benefits of measures to improve the water status (Guimarães et al., 2012; Qiu and Dosskey, 2012; Willaarts et al., 2012; Bai et al., 2011; Loomis et al., 2000; Greenley, 1981). These allow the gathering of quantitative and qualitative information, useful to understand the context and to identify the most suitable measures in specific areas. It is also useful for wider management, planning and policy making purposes.

Monetary assessments

It is out of the scope of this study to review the existing evidence on monetary valuation of ecosystem services, which is rather focused on reviewing studies providing the scientific evidence of the wider services delivered by measures to improve water quality. However, when reviewing these studies, we have identified that a number of them also include monetary valuations.

Most studies used the contingent valuation method, based on the estimation of individual's willingness to pay (WTP) to assess the benefits of the implementation of the measures. In most of the cases the final results the monetary studies show that the benefits have a higher monetary value than the costs of the measures (Guimarães et al., 2012; Townsend et al., 2012; Bai et a., 2011; Borin et al., 2010; Crossman et al., 2010; Guo et al., 2000; Loomis et al., 2000; Le Maitre et al., 2007).

4. Methodological approach to the identification of wider benefits in REFRESH

The methodological approach adopted for the identification of wider benefits of mitigation/adaptation measures aiming to improve water quality was initially identified in the REFRESH Description of Work (DoW) document.

Further to the above, and in accordance to the project DoW document, it was decided during the course of the project (Martin-Ortega and Skuras 2012) that wider benefits would be flagged and described in a qualitative manner, through the utilization of expert and stakeholder consultation, as part of the general WP6 stakeholder consultation process.

Within this context, the three main pillars of the methodological approach involved:

a) the identification of stakeholders;

b) a preliminary identification of main costs, benefits, cost-bearers and beneficiaries of water quality improvement in the selected catchments; and

c) a preliminary identification of wider benefits specific to the chosen mitigation measures for each catchment.

Stakeholders were identified following the guidelines developed for the "Collaborative scoping of solutions workshops" (Task 6.3) by Varjopuro et al. (2011). Hence, a classification based on the degree of stakeholder power and interest with respect to catchment-specific pressures was utilized. In some cases (e.g. Dee, Thames, Louros) local officers involved in projects associated with catchment management were consulted in order to ensure that a broad variety of local actors were consulted. Also, stakeholders which participated in the Task 6.3 workshops were consulted. Further, the choice of mitigation measures and their correspondence to specific sectors and activities influenced in some cases, the choice of stakeholders; indicatively, in the Greek case study, the focus of the chosen measures on agriculture resulted into a higher comparative representation of stakeholders associated with this particular sector. Finally, as increased attention was paid on acquiring knowledge on wider benefits which requires understanding from an ecological, recreational, local and policy decision-making perspective, scientists, biodiversity and conservation experts were approached in addition to stakeholders with decision-making jurisdictions.

The preliminary identification of main costs, benefits, cost-bearers and beneficiaries of water quality improvement in the selected catchments was pursued through screenings of catchment-specific conditions and expert consultation (e.g. JHI researchers). As noted below, the preliminary identified costs, benefits, cost-bearers and beneficiaries were presented to the workshop participants in order to "trigger" the relevant discussion. It is worth noting here that in the case of the Lake Pyhäjärvi workshop, this particular identification was carried out through the utilization of a cognitive procedure in the workshop.

The preliminary identification of wider benefits was carried out through literature review on wider benefits of improving water quality in freshwater systems (see Section 3 of this document) and expert consultation, through which examples of wider benefits specific to the mitigation measures chosen for each catchment were identified. Preliminary identified wider benefits were not disclosed to stakeholders participating in the workshops.

Taking the above issues into account, the tasks of the workshops were defined as follows:

i) Gather local stakeholder knowledge and views on the potential costs, cost-bearers, benefits and beneficiaries of water quality improvement measures in the sub-catchment.

ii) Gather local stakeholder knowledge and views on the proportionality and distribution of these costs and benefits across the sub-catchments society.

iii) Gather local stakeholder knowledge and views on the potential wider benefits beyond the water environment resulting from water quality mitigation measures.

In summary, the preparation of the workshops involved:

- The definition of the workshop aims.
- The identification and recruitment of stakeholders. Stakeholders were contacted by various means (email, letter, telephone).
- Logistic preparation including booking a venue, preparation of outline, organizing equipment and facilitation of responsibilities.
- Workshop design, which included the categorization of the chosen measures, the preliminary identification of costs, benefits, cost-bearers, beneficiaries and wider benefits through expert consultation and scientific literature review (see above).
- The preparation of a brief presentation on the aims of REFRESH and more specifically WP6, a summary of previous workshop and the objectives, outline and agenda of the current workshop.

Due to catchment-specific conditions associated with the availability of stakeholders[4] the organization of the six workshops did not coincide time-wise. The Dee (Martin-Ortega et al. 2012a) and Thames (Martin-Ortega et al., 2012b) workshops took place in September 2012. The Lake Pyhäjärvi workshop took place in December 2012 (Varjopuro et al. 2013), while workshops in the Czech Republic (Slavíková et al. 2013) and Greece (Skuras and Psaltopoulos 2013) were organized in February 2013. Finally, due to stakeholder fatigue, the Norwegian case study was first investigated through stakeholder interviews (Holen and Skarbøvik, 2013), followed by a workshop in October 2013.

Finally, investigations were specific to the chosen demonstration catchments, i.e. similar to the case of the Cost Effectiveness and Disproportionality Analyses.

[4] For example, in the case of the Norwegian catchment, stakeholders are very regularly consulted, so any new engagement has to fit into this schedule.

Workshop participants varied according to each context. In the Dee workshop, fifteen participants included representatives from the Scottish Environment Protection Agency, the Scottish Natural Heritage, the Scottish Government Rural Payments and Inspections Department, Scottish Water, the Royal Society for the Protection of Birds (in addition to a local ornithologist), the Dee Catchment Partnership and Local Biodiversity Action Plan Management Team, two members of the local Community Council, and representatives of the local sailing clubs and the farming community. The Thames workshop was attended by twelve participants, including representatives of the Environment Agency, Natural England, Thames Waters, two freshwater ecology scientists, two dairy farmers, representatives from three independent nature conservation organizations and a local inhabitant representing angling club interests. The Lake Pyhäjärvi workshop was attended by 15 participants, which represented water protection expertise, farmers, nature conservation administration and broader economic aspects (a municipality business developer). Ten stakeholders attended the Louros workshop; they included representatives of the Local Organizations for Land Reclamation (TOEB), of the farming community (farmers specialized on crops associated with the chosen mitigation measures), of fish farming and environmental tourism interests, of Amvrakikos (Natura 2000 site) Management Body and the mayor of Preveza. The Vltava workshop was the larger one in terms of participation (more than 40 stakeholders attended); these include representatives of municipalities, pond owners and managers, farmers, state water managers and ministries, academia and tourism entrepreneurs. Finally, in the case of Norway, interviewees included stakeholders, which participated in the “Collaborative scoping of solutions workshop”; these included farmers, representatives of local government, of recreation interests (e.g. hunting, fishing, boat club, etc.), of the Hydropower Company, and the Morsa River Basin District Authorities.

The organization of workshop discussions also varied in accordance to contextual factors and stakeholder participation. The identification of costs, cost-bearers, benefits, beneficiaries and wider benefits was facilitated through break-out group discussions in the Dee, Thames and Vltava workshops. However, in the (relatively smaller) Finish and Greek workshops, it was preferred to ensure discussion in one group, so that views from different interests are exposed to all participants.

5. Results in the demonstration catchments

Following the presentation of the aims of and methodology adopted in the six workshops, this section presents the results of the workshop discussions. First, there is a presentation of results of discussions on the identification of costs, cost-bearers, benefits and beneficiaries of mitigation measures aiming to improve water quality. This is followed by results of discussions on the proportionality and distribution of costs and benefits. The third section deals with the outcome of workshop discussions on flagging the wider benefits of improving water quality.

5.1 Identification of costs, cost-bearers, benefits and beneficiaries of measures aiming to improve water quality

Stakeholders participating in the workshops were first introduced to the concepts of cost and benefits to the society associated with measures targeting the improvement of water quality. Then, participants were asked to consider potential costs, cost-bearers, benefits and beneficiaries associated with the chosen mitigation measures in each case study. A preliminary list (one per workshop) of cost-bearers and beneficiaries was presented to participants and discussed; stakeholders were asked to validate the list and (if applicable) specify additional elements or/and elements judged as irrelevant in each context. Further, participants were asked to provide their opinion on each of the identified costs, cost-bearers, benefits and beneficiaries.

In general, the identified costs and cost-bearers were mostly specific to the chosen mitigation measures and activities associated with them, while benefits and beneficiaries largely seem context-specific. Also, as probably expected, costs of protection measures are borne upstream and benefits are enjoyed downstream. Rather few anthropogenic sources of pressures exist, affecting the welfare of a rather large number of people. Also, the preliminary lists of cost, benefits, cost-bearers and beneficiaries prepared by the WP6 research teams proved to be quite comprehensive and "accurate", though in some cases, further elements were added by stakeholders participating in the workshops.

In terms of costs and cost-bearers, the frequently identified and classified as important are costs to farmers mainly in the form of both increased farm costs and reduced yields, which are due to the reduction of pesticides and chemical fertilizers (Dee, Thames, Lake Pyhäjärvi, Louros) and changes in tillage practices and agricultural production patterns (Vansjø-Hobøl) foreseen by the chosen mitigation measures. In fact, in most of the above catchments it was perceived that the costs which the farm sector has to bear are rather significant, and could even risk the viability of a large number of farmers which would face a decline in their incomes (e.g. in the Louros case). Further, it was suggested that these costs were specific to crop farming, and that livestock dominated systems would not face a notable burden, with the possible exception of Thames. On the other hand, not all measures envisaged for farming seemed to be associated with significant costs (e.g. two-meter buffer strips in Dee, measures associated with grassing and no-tillage practices in Vltava). Also, in some cases farmers were also indicated as cost-bearers of maintenance costs of (e.g.) field drains and pasture pumps.

Within this context, it was often suggested that the likely granting of support for the implementation of such measures (e.g. through agri-environmental measures supported by Rural Development Programmes) would lead into the (at least) partial transfer of these costs to the taxpayer. However, stakeholders were not sure whether such support would be able to compensate for increased farm costs. Finally, it was also suggested that the improvement of farm practices associated with chosen measures such as buffer strips in marginal land, nutrient management could in some cases (e.g. Dee, Louros) lead to an improvement in yields.

In some case studies, stakeholder argued that agriculture was not the only cost-bearing economic activity and that other activities would bear costs associated with the chosen measures. These include quarry (which had already invested in capturing sediments) and forestry (facing the perspective of yield and harvesting losses) in the Dee, and most significantly, the fishery sector in Vltava which is facing a very significant reduction in carp production if the chosen measures are implemented.

Water and drainage/sewage treatment authorities (including local councils) were also noted as important cost-bearers due to the foreseen increase in treatment and compliance costs, though in most cases these particular costs were rather expected to be transferred to the taxpayer or/and the general public through higher water tariffs. Such examples include Scottish Water (Dee case study) which in addition to water treatment, was expected to bear the costs of maintaining Sustainable Urban Drainage Systems (SUDS); Thames Water (Thames case study) which is expected to face additional costs associated with sewage and the treatment of water for human consumption, SUDS enforcement, monitoring and reducing road and housing run-off, as well as maintenance costs; and in the Vansjø-Hobøl catchment, in which case the local water supply and sewage company was specified as a cost-bearer, while treatment costs specific to Municipal Sewage Treatment Plants and monitoring were expected to increase. Also, water protection authorities have already “shouldered” costs associated with waste water treatment and water quality improvement in Lake Pyhäjärvi (Varjopuro et al., 2010). However, the most significant costs (57 per cent of total costs of the chosen measures) associated with this type of cost-bearer were denoted in the Vltava case study and were specific to municipality actions on sewage treatment intensification and sewerage renewal.

Private households were also identified as another important cost-bearer. These costs are associated with septic tank connection to sewage treatment works and septic tank management, which both can be rather expensive “exercises” (Dee and Vansjø-Hobøl case studies); and septic tank registration (Thames)[5]. Other costs to private households in the Dee included water treatment for private water supply from the Estates, which incurs due to the fact that several households prefer to pay the Estates rather than join the public water supply system.

In the case of Thames, the Environmental Agency was also identified as an important cost-bearer (with costs end up to the taxpayer), due to foreseen monitoring and inspection costs associated with septic tank registration and management. Also, in the Dee an additional cost related to the dredging of sediments was identified.

Though it can be possibly argue that the specification of costs and cost-bearers led to rather “narrow” range of correspondence, the same cannot be argued for benefits and beneficiaries. Stakeholders participating in the demonstration catchment workshops indicated a wide range

[5] Though stakeholders expressed doubts if septic tank management should be included as an additional cost associated with the WFD.

of benefits and beneficiaries within recreation, commercial activities, biodiversity and the wider population.

In more detail, benefits associated with recreation were considered as the most important. In the Dee catchment, such benefits correspond to activities such as sailing (views expressed suggested a longer season and a higher number of participants), open access activities such as canoeing and windsurf, bird watching and a possible increase of recreational fishing activities. In the Thames, identified recreation beneficiaries include walkers and nature enthusiasts as well as recreational (local) anglers. In both cases, both the local population and visitors were expected to benefit from a higher-quality recreational environment.

Stakeholders participating in the Lake Pyhäjärvi workshop indicated a very wide range of benefits and beneficiaries. In terms of recreation, beneficiaries include local inhabitants and leisure time visitors, which were in total estimated to 22,000 recreational users of the lake. Within this context, recreational activities which would benefit from the chosen mitigation measures include kayaking and boating, swimming (which is very sensitive to water quality), recreational fishing which is very popular in the area, hunting of water birds and other recreational uses such as skiing on ice and boating. In Vltava, recreational activities, which would benefit from the mitigation measures include bathing, fishing and boating. Recreational benefits were also specified in the Louros workshop (e.g. canoe, swimming, walking). However, the perception (by visitors) that the river environment is in a satisfactory condition and the lack of tourism infrastructure in the area both led to the expression of considerable doubt regarding the capacity of the area to attract more than day visitors. On the other hand, some stakeholders argued that farm practices and illegal activities are well known to foreign visitors and constitute important constraints to the development of ecotourism in the area; thus, an improvement in water quality would benefit recreational activities. Finally, improved water quality in Vansjø-Hobøl (an important recreational area both locally and nationally) is expected to benefit local anglers and recreational users including hiking and general outdoor life for both local residents and visitors.

Several productive activities were also identified to benefit, especially from an increase in demand for recreation. In the Dee, it was argued that economic benefits would increase for sailing clubs and the Estates issuing licenses for sailing and perhaps, fishing. However, beneficial knock-on effects on the local economy (e.g. pubs, shops, accommodation) were considered as rather limited, as the vast majority of visitors is in fact, local. However, in the Thames, stakeholder opinion projected benefits for local businesses serving recreational users, including anglers. A wide range of commercial beneficiaries were specified in the Lake Pyhäjärvi workshop; these include activities serving recreational house owners (i.e. construction sector, groceries, etc.) but also activities such as commercial fishing (if the restoration fishing project which targets commercially non-attractive fish continues), and tourism-related activities such as fishing tourism and renting of cottages. Also, local paper mills and food sector units using water in their processes (including cooling) are expected to benefit from improved water quality. As already noted, knock-on effects on tourism-related business in Louros were projected as rather marginal, due to the lack of the relevant tourism infrastructure, but this could change in the longer term. However, benefits were projected for fish farmers and fishermen, associated with a certainty that the fish population would increase due to the chosen measures. Within this context, it was also argued that such a development would trigger an increase in fish tourism in the area and to positive income and employment repercussions for the local economy.

In Vltava, tourism-related activities were projected to benefit from water quality improvement; these include providers of camping sites, owners of accommodation units, providers of other recreational services such as restaurants and docks for yachts and owners of private cottages. Czech stakeholders also noted that extra revenue would be created for municipalities through leisure-time fees included in accommodation prices and the increased income tax of tourism-related entrepreneurs. Finally, local businesses are expected to benefit from increased recreational activity in Vansjø-Hobøl (e.g. commercial recreational fishing, local accommodation units, etc.).

Further to the above, in some cases it was argued that an improvement in farm practices (foreseen by the chosen mitigation measures) would benefit farmers. In the Dee, it was noted that these include nutrient management, more efficient fertilizer and better quality in the burns and livestock fencing, which would lower the risks of spreading animal diseases. In the Thames, increases in pollinators and natural predators would reduce pests, while in Lake Pyhäjärvi, it was argued that farmers would benefit from the use of higher-quality water for irrigation. In Louros, workshop participants indicated that farmers participating in agri-environmental programmes would benefit; also, they suggested that another positive effect with the chosen mitigation measures seems to be associated with an improvement in the market prospects of farm products produced in the area through environmentally friendly methods. Stakeholders argued that such an improvement could be important especially for citrus fruit. However, a vast restructuring of the marketing strategies and distribution channels was specified as a sine qua non condition for any positive market prospects for these products.

Regarding biodiversity, several benefits were also identified. In the Dee, it was argued that the removal of weirs and dams might increase the salmon population in the streams. Also, improved water quality would contribute to a general ecosystem improvement and to better habitat and wildlife health. On the other hand, some stakeholders argued that an increase in recreational use could have negative impacts on wildlife, while the possible attraction of more geese would be a source of water pollution. Biodiversity was also pointed out as an important beneficiary in the Thames, where an increase in fish populations was amongst others, noted; however, in addition to measures affecting water quality, the need for a more holistic approach on the issues and measures affecting biodiversity was emphasized. In Louros, a very likely increase in the fish and birds populations was identified, while generally positive effects for biodiversity were noted in Vansjø-Hobøl.

Finally, benefits for local households and the wider population were identified. These include better quality of life derived from the aquatic habitat improvement (all catchments), better quality water for drinking (Louros, Lake Pyhäjärvi, Vansjø-Hobøl) and use in the sauna

(Lake Pyhäjärvi). Also, in some cases (e.g. Lake Pyhäjärvi), stakeholders argued that environmental improvement caused by the chosen measures will enhance the reputation and attractiveness of the local area.

5.2 Proportionality and distribution of costs and benefits

Once a consensus was reached on the costs, cost-bearers, benefits and beneficiaries, stakeholders were asked to provide their views on if benefits will be higher that costs or vice-versa (disproportionality) and on if costs and benefits are well-balanced across the local community in each catchment (distributional effects).

Stakeholders expressed some general opinion on costs and benefits; they argued that costs are more concrete, short term and concentrated in a specific sectors/activities, while benefits are more abstract, subjective and longer term, and therefore, more difficult to estimate[6]. Also, it was pointed out that beneficiaries are not only humans and included aspects such as biodiversity and the catchments themselves. Also, costs linked to the chosen mitigation measures were perceived as compulsory, in contrast to the “opt-in” and perhaps uncertain nature of benefits. Simply, this means that beneficiaries could choose to enjoy (or not) the improved water environment, while cost-bearers are not given an option. Hence, it was considered very likely that costs and benefits might not be borne by the same people.

Taking the above into account, it was possibly hardly surprising that in some cases, workshop participants found it difficult to determine whether costs of improving water quality would be higher or lower than the benefits. Such case studies include the Dee, where stakeholders also debated on if costs related to compliance with regulatory requirements should also be compared to benefits. In the Thames, stakeholders suggested that a pristine environment was an unrealistic goal, which puts excessive demands for cost-bearers. However, some stakeholders argued that in the long term, benefits outweigh costs, and thus, the chosen water quality improvement measures are justified.

In the Lake Pyhäjärvi workshop, stakeholders argued that there is a lot of uncertainty regarding the estimation and comparison of costs and benefits; however, the general perception was that due to the importance of the Lake as a local/national recreational area, benefits would be higher than costs. In Louros, stakeholder opinion vastly differed; stakeholders associated with farming interests argued that benefits would be much lower than costs associated with the chosen mitigation measures, which were specific to the crop sector. On the other hand, stakeholders with environmental interests suggested that benefits associated with ecotourism and an environmentally sound crop sector would be significantly higher than the costs of the mitigation measures.

In Vltava, stakeholders seemed to be aware of the importance of benefits associated with water quality improvement. However, the capacity to pay seemed to be very low, especially in the case of stakeholders associated with production sectors (fisheries, farming). These stakeholders considered themselves as net cost-bearers, argued that it adaptation of their

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[6] It was argued that costs would happen upstream, while benefits would mostly occur downstream.

practices was very difficult and insisted that (ultimately) these costs should be subsidized and hence, borne by taxpayers. Finally, in Vansjø-Hobøl, stakeholders argued that though it is difficult to make a monetary assessment, benefits of improving water quality outweigh costs.

With regards to distributional effects, the general opinion of stakeholders already presented (see above) and the focus of measures towards specific economic sectors and human activities led to inference on the uneven distribution of (especially) costs and also benefits. Indicatively, in Louros it was argued that costs would be entirely borne by crop farmers, which would enjoy very few benefits from improved water quality. Also the fact that other activities polluting the river are not associated with any measures generates a very uneven distribution. Also, the existing weak institutional environment and its low efficiency in monitoring and inspections made this view quite strong. Stakeholder opinion was rather similar in Lake Pyhäjärvi, where again farmers were assessed as the sole cost-bearers[7], while benefits correspond to a very wide range of beneficiaries.

In Vltava, stakeholders argued that costs are unevenly distributed against the fisheries sector, which will enjoy very few benefits from improved water quality. In the case though of municipalities, it was argued that the distribution of costs for their budget and benefits for their residents does not seem uneven. An uneven pattern of distribution of costs and benefits seemed to be the case also in Vansjø-Hobøl, in which case it was argued that they are not borne by the same people. Even though there is a consensus on the importance of good water quality, actors facing the higher relative costs such as farms and residential buildings were assessed to be associated with comparatively low benefits, as soon as water quality is acceptable for irrigation.

5.3 Flagging the wider benefits of improving water quality

Subsequently, stakeholders were briefed on the concept of wider benefits, i.e. those derived for water quality improving measures and affecting other ecosystem goods and services. As already noted, the WP6 research teams had undertaken a literature review on wider benefits and subsequently, a list of wider benefits specific to each case study was produced. These lists were not disclosed to workshop participants but were utilized for stimulating the relevant discussion. Stakeholders were then asked to indicate both measure-specific and "general" (i.e. linked to improved water quality) wider benefits and also comment on the short-term or longer-term nature of those benefits.

In general, stakeholders participating in the workshops were able to identify a wide range of wider benefits associated with improved water quality in the selected catchments. However, the range of wider benefits identified varied considerably between catchments; in some cases (e.g. Dee, Thames, Lake Pyhäjärvi, Vansjø-Hobøl) several wider benefits were identified, while in others (e.g. Louros, Vltava), respondents were more restrained in the identification of such benefits. Also, as possibly expected, it generally proved rather "easier" for

[7] Though it was noted that taxpayers would borne the costs of mitigation action subsidized by agri-environmental measures.

stakeholders to identify wider benefits associated with water quality, than those strictly associated with each of the chosen mitigation measures.

Considering that the categories of wider benefits presented in this document (see Section 3.2) constitute a satisfactory basis, it is used here for classifying benefits identified in the workshops. In general, stakeholders mostly identified non-water wider benefits, followed by non-strictly water ones. Strictly water benefits were also suggested, however, as noted in the REFRESH Description of Work document and the introductory section of this report, the main focus of Task 6.5 is to assess the impact of the chosen mitigation measures on other ecosystem goods and services.

In the case of strictly water benefits, in the Dee it was reported that riparian woodlands and buffer strips would contribute to improved water retention in the catchment, reduce flooding and improve biodiversity. Also, measures to reduce run-off from housing development were thought to have positive effects in terms of reducing flooding. It was also noted that the improvement of septic tank management would lead to lower risks of contaminating water supplies. Despite some suggestions on the lack of faith in the potential to improve the water environment in the Thames, stakeholders argued that reduced flooding would be an overall benefit of better water quality management, and specific measures such as improved monitoring and awareness, and decreased run-off which would also benefit fish recruitment.

In Lake Pyhäjärvi it was noted that measures associated with agriculture would benefit water turbidity, fish and crayfish recruitment, water vegetation, plankton populations and generally would positively affect the catchment's hygiene status. Also, non-agricultural measures such as sewage treatment and wetland management would improve the state of the lake, control the flow of river and flooding and also provide shelter and spawning area for fish. In Louros, stakeholders argued for significant benefits of mitigation measures on fish recruitment and on the deterrence of the prevalence of species such as jellyfish, while in Vltava, flood protection was emphasized as an important wider benefit. Finally, improved fish population was also noted as a strictly water benefit in Vansjø-Hobøl.

As expected, several non-strictly water benefits were reported by stakeholders. In the Dee these include biodiversity gains associated with specific measures (e.g. increase in the population of bees due to better farm practices; wildlife due to riparian woodlands and buffer strips), but also benefits on aesthetic values and recreation associate with the general improvement of water quality. Also, a healthier environment with clean waterways was considered to increase the value of agricultural land and generally, property, while increased community wellbeing was also raised as an issue, as improved water quality would generate a sense of local pride and local participation. In the Thames, biodiversity benefits were emphasized. Discussions on specific measures led to suggestions that species would benefit from flexible field margins and buffer strips, which would also help with erosion control. Improved monitoring could amongst others, benefit soil nutrient cycles. In Lake Pyhäjärvi an improvement in biodiversity and aesthetic value was associated with measures such as winter vegetation, nature management fields, buffer zones and wetlands management. Also, recreation benefits are associated with restoration fishing. In Louros, the chosen mitigation measures are expected to benefit the bird populations and in general, biodiversity, while important benefits for biodiversity and soil erosion were reported in Vltava. In the case of Vansjø-Hobøl, it was argued that changes in farm practices would lead to improved soil retention, and increased aesthetic values and recreational benefits.

In the Dee, it was generally argued that an improvement in water quality would have a positive effect on human health and wellbeing. Wider non-water benefits also include the improvement of pollination and pests control in fields associated with riparian woodlands and buffer strips, while an improvement in the management of septic tanks is related to less risk on human health. Stakeholders also argued that the improved ecological status of the waters is linked to educational benefits for the younger generations and help raising awareness of the environmental consequences of public behaviour and potentially stimulate pro-environmental attitudes. Also, it was mentioned that benefits would be passed through the food chain, as better soil quality and nutrients will circulate all the way up to food production.

In the Thames, water quality was associated with higher level of human welfare and also as a means to "combat" climate change. Changing farm practices were linked to the improvement of pollination, pests control and have a positive impact on crop production. Also, stable grasslands and permanent pastures would positively affect carbon sequestration and storage. More important, participants highlighted the potential for cumulative positive impacts of environmental schemes, as farmers become more confident in environmental regulations and stewardship scheme uptake when they see the benefits, including benefits to their own wellbeing and the wider community. Also, perhaps more generally, the chosen measures were perceived as potentially positive for climate change mitigation and adaptation, awareness-raising, and long-term changes in attitudes towards environmental sustainability.

In Lake Pyhäjärvi notable economic benefits were associated with measures such as reduction of fertilization, organic farming and buffer zones. Sewage treatment would have positive effects on employment and improve hygiene for local households. Restoration fishing was also associated with economic benefits.

In Louros, it was widely acknowledged that living in an environment with clean waterways has a general positive effect on human health and wellbeing. Also, the positive repercussions of better water quality on the food chain was acknowledged and also linked to soil quality improvement. On the other hand, stakeholders expressed their skepticism on impact of the current "clean environment" perception associated with the state of the Louros area. It was argued that such a perception constraints the understanding (on behalf of local, regional and central decision-makers and institutions, local population and visitors) of the need to apply environmental protection measures and ultimately, restricts the development of wider benefits.

Finally, in Vansjø-Hobøl, improved farm practices were linked to the acquisition of knowledge on the impacts of farming on water quality, to the enhancement of the recognition of the water quality improvement status of farmers, and to increased cooperation among farmers. Improved septic tank management and sewage works was associated with increased capacity for population growth and residential property development and increased cooperation between neighbouring households. In general, water quality improvement would improve livelihoods and public health, increase scientific knowledge, increase the sharing of knowledge from science to citizens, politicians and public administration and enhance environmental awareness among farmers and households and improve general environmental behaviour in the communities of the catchment.

6. Conclusions

This report aims to discuss the role of wider benefits in the economic analysis of water quality improving mitigation actions in the analysis of disproportionality and also present the results of stakeholder workshops on the identification of wider benefits in the demonstration catchments.

A review of the existing scientific literature has proved that there is a significant and wide range of wider benefits associated with the implementation of measures to improve water quality, although evidence is skewed towards certain specific measures (e.g. buffers strips) while there is much less information on other. Most of the evidence is based on modelling approaches that are subject to some degree of uncertainty. Biodiversity, diffuse pollution, carbon storage, flow regulation and soil erosion control are the most notorious additional benefits identified in the literature. There is also evidence of the existence of less tangible benefits such education, cultural and amenity values.

The stakeholder workshops generated valuable input on the identification of costs, cost-bearers, benefits and beneficiaries of mitigation measures aiming to improve water quality; the proportionality and distribution of costs and benefits; the flagging of the wider benefits of improving water quality. Also, in the two UK workshops, a participatory mapping exercise was implemented.

In general, identified costs and cost-bearers were mostly specific to the chosen mitigation measures and activities related to them, while benefits and beneficiaries seem to be mostly context-specific. Costs and cost-bearers identified and classified as important include increased farm production costs and reduced yields; such costs were suggested as a rather heavy burden to the farm sector though this was not the case in all catchments. Also, the likely transfer of at least a part of these costs to taxpayers (through the funding of agri-environmental measures) was pointed. Also, other productive activities were indicated as cost-bearers, including quarrying, fisheries and forestry.

Water and drainage/sewage treatment authorities were also noted as significant cost-bearers in some catchments, while private households were expected to bear costs associated with septic tank management.

Benefits and beneficiaries identified correspond to rather wider range than that associated with costs and cost-bearers. Important recreational benefits were identified in all case studies.

Also, several productive activities were identified to accrue benefits especially from an increase in the demand for recreation. Farming was a further productive sector linked to benefits associated with mitigation measures; such benefits include the prospects of a healthier productive environment as well as better market prospects for farm products produced in an environmentally-friendlier way.

Biodiversity benefits were also identified including those associated with species populations and wildlife health. Finally, an improvement of the quality of life for households was identified and included various aspects such as habitat improvement, better quality water for drinking and enhance reputation for the catchment areas.

Regarding proportionality, it was argued that costs are more concrete and short term, while benefits were more abstract, subjective and longer term. In some cases this led to difficulties in the comparison of costs and benefits. However, there was a general opinion that benefits outweigh costs, despite their long term and "uncertain" nature. Also, issues influencing such a comparison were discussed, including the heavy burden of mitigation measures on productive activities such as farming in Louros and fishing in Vltava.

In general, stakeholders argued that costs and benefits are unevenly distributed. Specific sectors and activities seem to be associated with most of the costs, while benefits seemed to correspond to a rather wide range of actors.

In accordance to the objectives of Task 6.5, identified wider benefits were mostly non-water and non-strictly water ones. Main non-strictly water benefits identified include biodiversity conservation, soil conservation, and increase of amenity and aesthetic values. In fact the above-mentioned wider benefits were associated with both the general improvement of water quality and specific measures. In addition, wider benefits, which include the increase in property values and also local pride and participation were noted by stakeholders.

Without downplaying the importance of strictly water and non-strictly water benefits specified, stakeholders seemed to be convinced that at least in these case studies, a significant range of non-water wider benefits would occur. This finding can be perhaps justified by the variation of case-study specific contextual factors and the fact that such wider benefits are associated with a wide range of beneficiaries. Hence, improvements in human health and wellbeing, gains in economic activity (including employment), educational resources and changes in attitudes towards environmental sustainability, and food security were denoted. Further, water quality improvements were associated with wider benefits such as pest control, climate change, retention of nutrients and organic material, air filtering, improvement of pollination, and generally, reduced environmental impacts. However, it is worth noting that in several cases, stakeholders noted that often such benefits are linked to several other, rather complex factors such as perceptions on the state of the environment, development strategy capacity at the local level and economic factors influencing productive behavior; hence, it was argued that the influence of these factors on behavior of catchment specific economic and social actors would influence the development of these wider benefits. Finally, with the exception of the Louros case study (Skuras et al., 2013), wider benefits identified in the Task

6.5 workshops further support findings of Task 6.4 on the existence of proportionality (see Balana et al. 2013; Martin Ortega et al. 2013b; Varjopuro et al. 2013b; Vojáček et al. 2013; Skarbøvik et al. 2013) and confirm that the chosen mitigation/adaptation measures would generate social benefits.

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Annex: Review of existing evidence of the benefits of improved water quality

Reference	Measure	Location	Context	Strictly water benefits	Non-strictly water benefits	Non-water benefits	Approach	Limitation/ Uncertainty	Monetary benefits
Borin et al. 2010	Implementation of Buffer strips and/or Riparian area conservation/restoration	Veneto Region (North-East Italy)	Eutrophication problems caused by herbicides, No3-N, phosphorous from farming areas (maize, soyabean and sugarbeet).	Control of diffuse pollution from croplands	Aesthetic value	Timber production Carbon storage Improving in soil fertility	Experimental Stakeholder Judgement Modelling	MOP model suffers limitation associated generally to linear programming	CO_2 value is 1280-2320 € ha^{-1} $year^{-1}$
Qiu and Dosskey, 2012	Implementation of Buffer strips and/or Riparian area conservation/restoration	Neshanic River Watershed (New Jersey, USA)	Poor water quality as a result of the extensive urban development and agricultural land use.	Stormwater mitigation Flood regulation Control of diffuse pollution leaving croplands and urban development	Biodiversity conservation Amenity value	Soil erosion control Green Corridors Carbon storage	Expert Judgment Experimental	-	-
Sahu and Gu, 2009	Implementation of Buffer strips and/or Riparian area	Walnut Creek watershed,	High levels of No3-N and sediment outflow from	Control of diffuse pollution	-	-	Modelling	Buffer strip efficiency will depend on several	-

	conservation/restoration	(Iowa, USA)	intensively cropland of corn and soybean to the river.	from croplands				factors such as field size, slope and rainfall pattern.	
Everard et al., 2012	Integrated constructed wetlands (ICWs)	Anne Valley in Waterford (Ireland)	Poor water quality produced by the over-riding management and agricultural products application and dairy activities.	Control of diffuse pollution leaving croplands and urban development Hydrological buffering Flood regulation Fish recruitment Angling	Aesthetics and Amenity value Biodiversity conservation	Carbon storage Green Corridors Educational resources Optimization of soil nutrient cycles	Experimental Expert/ Stakeholder Judgement	-	-
Guo et al., 2000	Reforestation, revegetation and forest conservation	Yangtze river (China)	Relationship between flown control by forest and hydroelectric power plant production.	Flow regulation Improvement in Hydroelectricity production	Recreation	Timber production Fruits recollection	Modelling	-	Additional value of electricity production by water flow regulation: $1,465,772 year^{-1}

				Flood control		Carbon storage Soil erosion control			
Yang et al., 2011	Change in agricultural practice (BMP such FDTs, fertilizer reductions, tillage methods, crop rotations)	Northwestern New Brunswick (Canada)	Widespread soil losses and degradation of surface water quality as a result of agriculture activities. (mainly potato)	Control of diffuse pollution from croplands	-	Soil erosion control Improvement of agriculture production	Modelling	Estimation of water quality indicators with experimental BMP combinations is unrealistic because the impacts at watershed level depend on many factors. -Model have difficulties in simulating N leaching during the snowmelt season The macrospore flow from no-till practice in the soil could not be simulated	-

Townsend et al. 2012	Reforestation, revegetation and forest conservation Land conversion (Farming areas to perennial pastureland)	Warren-Tone watershed, (South Eastern Australia)	Mitigation of water salinity problems through planting higher water efficiency crops: plantation forestry, non-commercial revegetation and perennial pastures in farming areas (crops and pasture)	Reduction salt solute in water Reduction of eutrophication Reduction of damage to waterways by siltation Flow regulation Increment of water supply	Biodiversity Conservation Eco-Tourism Aesthetics value	Carbon storage Timber production Soil erosion control Protection of infrastructures	Modelling	The Lucicat programme does not incorporate the impacts of climate change	Benefits: $ 22 t CO2-e Benefits ranging from -$5 to $12.1 million year-1, depending on different discount rates Opportunity cost from revegetation saline and shallow soil is a reduction from $0.4 to $5.8 million year-1, depending on different discount rates. NPV of Commercial forestry operation $1.6 million year -1 with the highest discount rate.
Crossman et al. 2010	Changes in agricultural practice (Changes in irrigation) Reforestation, revegetation and conservation of the forest	Murray Darling Basis Torrumbarry Irrigation Area (Northern Victoria, Australia)	Water stress (low flow and salinity) from over-allocation of water to irrigation enhanced by drought and climate change.. Farm area (dairy, beef, cattle, gains and high value of	Reduction salt solute in water Flow regulation	Biodiversity Conservation Recreation Amenity value	Improvement of agriculture production Carbon storage	Modelling Stakeholder Judgement	-	NPV of services up to $347 millions $ 20/t CO2-e market price. River salinity: PV $0-4823

			horticulture)						ML^{-1} Stable climate: NPV \$ 4377-5404 ha^{-1} Productive agriculture: NPV \$1696-98490 ha^{-1} Environmental flows: NPV \$500-2200\$ ML^{-1} Recreation and amenity: PV \$96-642ha^{-1} The return of 62 GL of water would provide \$57.6 million to \$189.4 million in environmental flow and salinity reduction
Garmedia et al., 2012	Land conversion (Exotic plantation to Native forest or Pastureland)	Gipuzkoa (Basque Country, Spain)	Exotic plantation increases the sediment loads and decrease water flows decreasing water quality	Increment of water supply Improvement of water quality (less sediment load)	Biodiversity conservation	Soil erosion control Carbon storage	Experimental	-	-

Willaarts et al., 2012	Land conversion (to eco-cultural agroecosystem “dehesas”)	Sierra Norte (Sevilla, Spain)	Decreased flow of hydrological services due to land abandonment	Increment of water supply Water quality improvement (Multifunctional agroecosistem) Flow regulation	Recreation Biodiversity conservation	Improvement of agriculture production Meso-climate regulation Optimization of soil nutrient cycles	Modelling -Expert Judgement	-	-
Loomis et al., 2000	Buffer strips/ Riparian area conservation/restoration Change in agricultural practice (changes in irrigation and water management) Land conversion (cropland to pastureland)	South Platte River (Denver, USA)	Reduction of water quality and ecosystem services due to soil erosion and diffuse pollution from agriculture, enhanced by lack of riparian vegetation.	Dilution of wastewater Control of diffuse pollution leaving from croplands and urban development Increment of water supply Fish recruitment	Biodiversity conservation Recreation Aesthetic value Existence value Bequest value	Soil erosion control	Stakeholder Judgement	-	Annual benefits: $18.54 million $year^{-1}$

Jansson and Nohrstedt, 2001	Reforestation, revegetation and forest conservation	Stockholm Country (Sweden)	Increment of CO_2 emission by the city activities (cars and industry). The CO_2 absorption by forest and the water required for maintains the forest is calculated.	Flow regulation Control of diffuse pollution leaving from urban development	Recreation Cultural value	Carbon storage Noise reduction Air filtering Meso-climate regulation	Modelling	Model shows that the proposed program is not feasible (it would require conversion to forest of area 2.7 times the are of the country).	-
Bai et al., 2011	Land conversion (to Eco-agriculture with local features) Improvement in waste management (Recycling industries) Reforestation, revegetation and forest conservation	Mentougou District (Bijing, China)	Water services damaged due to coal mining	Increment of water supply Control of diffuse pollution leaving from croplands and urban development Flood regulation	Biodiversity conservation	Soil erosion control	Expert Judgement	-	Social benefits: \$18.50 million $year^{-1}$ Employment opportunities: \$2.43 million $year^{-1}$ Income per capita: \$6.05 million $year^{-1}$

Le Maitre et al., 2007	Change in agricultural practice (livestock reduction) Implementation of Buffer strips and/or Riparian area conservation/restoration (alien trees removal , soil stabilization and mini-catchment to improve infiltration)	Little Karoo, (South Africa)	Arid environment degraded by inappropriate agricultural practices such us folder crops, fruit, and vines and overgrazing since 1800	Increment of water supply Control of diffuse pollution leaving from croplands and urban development Flood regulation (Infiltration improvement) Water quality improvement (less sediment loads, improvement in agriculture practices) Groundwater recharge	Biodiversity conservation	Soil erosion control Retention of nutrients and MO. Improvement of agriculture production Improvement in soil fertility Employment opportunities Increment of ecosystem resilience to drough	Expert Judgement	-	Accumulated loss from 1996-2003 is £5.54 million. Average annual of loss: Water supply $529,839.8 year $^{-1}$ Water pollution $109,604.93 year $^{-1}$ Biodiversity loss $396,29.82 year $^{-1}$ Water disaster $136,76.45 year $^{-1}$ Annual loss $692,751 year $^{-1}$ between 1996-2003
Gordon et al., 2010	Change in agricultural practice (changes in irrigation and water management, reduction of fertilizes in	-	Water eutrophication, groundwater degradation, increased vulnerability face to	Reduction salt solute in water	Hunting	Improvement of human health (N and disease)	Expert Judgement	-	-

agriculture) Land conversion (to Multifunctional Agro-ecosystem and pasturelant to tree cover)	storms and flooding, habitat loss and negative impact on fisheries, due to agricultural practices (diffuse pollution and abstraction).	Control of diffuse pollution from croplands Reduce vulnerability to waterlogging Nutrient retention in wetland Angling Flow regulation (streamflow)	Recreation Cultural value Biodiversity conservation	Reduction of poverty Improvement of Pollination Improvement of agriculture production (e.g. Fiber) Timber production Reduced environmental impacts Carbon storage Food security Pests control

						Ecosystem resilience (by conservation of Biodiversity)			
Guimarães et al., 2012	Improvement in waste management (Treatment plant in 2010) Change in agricultural practice (Changes in water management increasing river discharge for greater flushing of the estuary) Dam removal	Guadiana Estuary in (Southwestern of Spain)	Reduction of water flown and ecological damages by the construction of over 50 dams. - Point source pollution (industrial and urban sewage work) in tourist area	Water quality improvement (Treatment plant in 2010) Flow regulation Reduction of damage to waterways by siltation	Biodiversity conservation Tourism Recreation	Employment opportunities Optimization of soil nutrient cycles	Modelling Expert and Stakeholder Judgement	Acquisition of data from highly diverse sources, revealing significant data gaps in the process.	WTP: € 47.14 CBA model indicates that the economic benefit surpass the cost by ca. € 3.1 million
Bednarek, 2001	Dam removal	Global	Changes in water flow, temperature and sediment load due to dam.	Water quality improvement Restoration of river flow (temperature and velocity (rapid-moving to slow-moving)) Improvement in	Biodiversity conservation and increment (native vs exotic sp.)	Green Corridors (e.g. salmons) Restoration estuary and costal and	Review	Absence of pre-removal sampling Lack of monitoring programs at privately owned dams.	-

				Hydroelectricity production (limitation by fine particules) Reduction of damage to waterways by siltation		habitats and biota			
Babatunde et al., 2008	Constructed wetlands (CWs)	Ireland	Problems with water quality by urban development pressures (including industrial effluents, urban and agricultural stormwater runoff, animal wastewaters, leachates, sludges and mine drainage)	Control of diffuse pollution leaving from croplands and urban development Prevention of foreign spices of plant and algae Retention of nutrients in the wetland	Aesthetic value Biodiversity conservation	-	Review	The septic tanks still predomínate the septic tanks (40% in Irland).. It is not the most suitable choose for the geologic conditions in this place and CWs could be a good alternative.	-

Source: Own elaboration.

MOP: Multi objective programming; BMP: Beneficial Management Practices; FDTs: Flow diversion terraces; N: Nitrogenous; t CO2-e: Tonnes of CO2 equivalent; GL: Gigalitres; MOP (Multi objective programming); BMP: Beneficial Management Practices