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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). This report presents the results of a cost-effectiveness analysis (CEA) for mitigation measures to abate eutrophication in the upper part of the Vltava catchment, the Czech Republic, and of a disproportionality analysis of costs of mitigation measures and benefits for improved water and ecological quality. The analysis focused on phosphorus (hereinafter referred as P) reduction from its major sources in the catchment of the Orlík Reservoir, i.e. municipal wastewater discharges, fishpond fisheries, and agriculture (arable and livestock).

The Orlík reservoir is burdened with excessive emissions of P from municipalities (55%), the fishery sector (22%) and agriculture (12%). A specific regional feature is intensive carp production in many ponds of different sizes. The starting point of CEA was an analysis of existing measures implemented in 2007–2015. Based on the information analysis, it was modelled that these measures would reduce the P inflow by approx. 22 tonnes (corresponding to 20% of the total necessary P reduction) at total costs of CZK 465 million (EUR 17 mil.) a year. The CEA then focused on creating a cost-effective scenario, the implementation of which would result in the total necessary phosphorus reduction, i.e. reduction of the P inflow to one half to prevent the massive algal blooms in summer months. Numerous measures for P reduction were identified in discussions with stakeholders and expert specifications. In total, 3,097 measure applications were analysed within the CEA (of which 1,610 qualified for the effective scenario). The total annual costs were CZK 602 mil. (EUR 22 mil./year).

The CEA analysis was followed by a benefit transfer analysis in order to calculate the benefits incurred by the water quality improvement. We focused on recreational benefits for residents and tourists. Furthermore, due to a lack of available data, we assumed other benefits and the future tourism development through expert judgments. Benefits were calculated on different time scales corresponding to the cost analysis. The first scenario calculated benefits between 2007 and 2015 amounting to CZK 256 mil. (EUR 9.5 mil.). The benefits in the case of the CEA scenario realisation were calculated in the second scenario (with expected lifespan of the measures being 20 years); we calculated benefits between 2016 and 2035 amounting to CZK 2,002 mil. (EUR 74 mil.).

The net social benefits in both the scenarios are negative, amounting to CZK -3,770 mil. (EUR -140 mil.) in the 2007–2015 scenario, and CZK -13,245 mil. (EUR -491 mil.) in the 2016–2035 scenario.

The cost-benefit calculations were then amended by stakeholder consultations that sought for the acceptability of the proposed scenario, distributional effects and wider effects caused by its realisation. Qualitative methods (focused groups, questionnaires) were used to capture those features. It showed a problem of financing the implementation of proposed applications of measures (small municipalities do not have the money to build the infrastructure; fish producers and farmers require subsidies to change their practices above legal requirements). Furthermore, fish producers denied their contribution to P releases to a large extent.

General introduction

The project REFRESH aims to help design cost-effective mitigation and adaptation strategies for freshwater bodies that lead to compliance with the Water Framework and Habitats Directives. Task 6.4 represents the core of the REFRESH project, because it includes the results of the Cost-Effective Analysis (CEA) of remediating strategies to achieve compliance with the Water Framework Directive. Along with that, this task also deals with assessing the (dis)proportionality of costs of measure implementation and benefits and exploring the differences in the behaviour and views of different stakeholders within the same catchment in this respect.

This report presents the results of Task 6.4 for the catchment of the Orlík Reservoir – the upper part of the Vltava catchment in the Czech Republic. The catchment of the Orlík Reservoir is situated in the south of the Czech Republic. The catchment covers an area of 12,117 km^2 and spreads in the territories of three European countries, i.e., the Czech Republic (92.2% of its total area), Austria (7.1%), and Germany (0.7%) and consists of several sub-basins. Each of the sub-basins faces different conditions. Geography includes different climate, geology, pedology, and hydrology conditions in a spectrum of locations ranging from river valleys and upland plains that are largely used for agriculture and urbanisation to forested, almost uninhabited mountainous regions. The density of the river network is 1.2 km per km^2, and approx. 16,000 man-made lakes (total area of 312 km^2) are present in the Orlík Reservoir catchment. The largest protected natural territory is the area of the Šumava Mountains. Its territory is protected both as a protected landscape area (PLA) and (core part) as a national park.

The Orlík Reservoir catchment belongs to a temperate, mildly cold climatic region and is positioned in a transient belt between the wet oceanic climate of Western Europe and the dry continental climate of Eastern Europe. The South Bohemian region has long been perceived as an agricultural area with developed fish farming and forestry. Cereals (wheat, rye), oilseeds (rapeseed, sunflower, poppy seed) and fodder prevail in the agricultural plant production. The production of potatoes and fruits (cherries, apples, currants, and plums) is also significant. The livestock production focuses on raising cattle, pigs and poultry. The fish farming has a long tradition.

There has been permanent settlement in the Orlík Reservoir catchment since the Palaeolithic period. The area of the South Bohemian region, which is almost identical to the Orlík Reservoir catchment, is 10,056 km^2 and represents 12.8% of the size of the Czech Republic. The region has about 643,000 inhabitants. České Budějovice is the largest urban settlement in the catchment. There are also numerous other settlements.

The economy of the area is largely dependent on water conditions and resources, but it can also pose a threat to the aquatic environment. The Orlík Reservoir catchment area does not belong among the key industrial areas in the Czech Republic. The industrial production is concentrated mainly in the urban area of České Budějovice and in the districts of Tábor and Strakonice.

The water quality has improved after 1989 due to the societal change and the pressure to improve nature conservation as well as application of EU standards. But even so, out of a total of 161 surface water bodies (WFD) in the administrative district of the South Bohemian region 17 are satisfactory (11%), 4 potentially defective (2%) and 140 defective (87%). Persistent problems can be seen in the ongoing inflow of inorganic nutrients, especially phosphorus, from point sources (sewage treatment plants and septic tanks) and diffuse sources (agriculture and fisheries) of pollution. The work presented here focuses on phosphorus reduction from point sources, agriculture and fisheries.

The CEA and the disproportionality analysis followed all the previous tasks of Work-package 6. This report consists of 3 parts. Part I is dedicated to the cost effectiveness analysis and results from this analysis. Part II describes in detail the analysis of (dis)proportionality. Part III contains conclusions of both analyses and policy implications and recommendations.

Part I: Cost effectiveness

1. General CEA approach

The assessment of the cost effectiveness of measures to improve water quality is based on a study of phosphorus inflow and outflow in the catchment of the Orlík Reservoir (Hejzlar et al., 2010), which coincides with the area of the upper Vltava River basin in the southern part of the Czech Republic.

This study produced a detailed model of phosphorus inflow and outflow for point and diffuse sources of pollution in the entire catchment of the Orlík Reservoir and a model of phosphorus retention in the river network between the source points and the entry to the lake. The model provides input data on pollution sources and retention in the watercourses in the lake catchment basin that are used for CEA.

The phosphorus reduction target was estimated based on the modelling results. After that, the possible measures to reduce phosphorus inflow were identified (wastewater, aquaculture, agriculture) and the effectiveness of the measures as well as the costs of the particular applications of the measures were estimated.

Then, two scenarios were defined in which the costs were analysed separately. The first scenario is an analysis of the water quality measures already applied between 2007 and 2015 and their effects in terms of phosphorus eliminated. In total, there were 179 applications of measures. Due to these applications, the export of phosphorus will decrease by no more than 22 tonnes after the implementation of all the possible measures by 2015, which is approximately 20% of the total reduction goal (of 136 tonnes). The second theoretical scenario is focused on the elimination of the remaining 114 tonnes. In this scenario, the cost effectiveness analysis was done and the effective scenario to reach the phosphorus reduction target was analysed and described.

1.1 The CEA approach and WP5-WP6 integration

In cooperation with REFRESH WP5, the model of phosphorus inflow and outflow was expanded with possible alternative measures leading to reduced contamination production. Due to the great differences among the sub-basins, their specific features had to be considered. For point sources (discharge points of municipal wastewater), the model considered the particular wastewater management situation in every municipality in the basin (e.g., rate of wastewater treatment, (non)existence of treatment plants and sewerage). For diffuse sources (aquaculture, agriculture), the model unit (77 km^2 on average) was based on the water bodies delineated and used in the Vltava River Basin Management Plan under the EU Water Framework Directive (WFD; Directive 2000/60/EU).

1.2 The CEA steps – description and implementation

The implementation of the CEA steps for the Orlík Reservoir catchment is based on the CEA Guidance Note (Balana, 2011) and presented below.

1.2.1 Identification of key pressures

The catchment basin of the Orlík Reservoir faces excessive phosphorus contamination and eutrophication of surface waters. According to the river basin management plan (RBMP) documents, phosphorus is the most important pollutant that compromises the achievement of WFD targets in the Vltava River catchment (Povodí Vltavy, 2009a,b). The principal problem is the high introduction of phosphorus via tributaries discharging into this man-made lake. The high input of phosphorus causes excessive enrichment of the water with phosphorus and eutrophication. The excessive trophic value of the water causes a notable reduction in the biodiversity of the aquatic ecosystem, excessive phytoplankton growth and algal bloom, resulting in worse water quality in the water sources and reduced recreational potential of the waters.

1.2.2 Identification of pollution sources

As shown by the above mentioned study of phosphorus inflow and outflow and nitrogen sources in the Orlík Reservoir basin (Hejzlar et al., 2010), the main sources of the phosphorus contamination in the lake are: municipal wastewater discharged into the watercourses, intensive aquaculture in fishponds, and farming in the catchment basin. Table 1 shows their respective shares in the contamination.

Table 1: Sources and discharge of phosphorus in Orlík Reservoir basin. Average annual values for 2007–2009.

Source/process	Orlík Reservoir basin	
	t/year	% of pollution sources
Wastewater	**143.0**	**55**
Fisheries	**58.3**	**22**
Agriculture	**31.4**	**12**
Unidentified sources	26.0	10
Municipalities	0.6	0.2
Atmospheric deposition on water bodies	1.1	0.4
Natural background	94.7	-
Total contamination in the basin	260.4	-
Total sources in the basin	**355.1**	**-**
P retention in the river network	66.9	-
Input to Orlík Reservoir	**288.2**	-

Source: Basin model of phosphorus inflow and outflow (Hejzlar et al., 2010)

Wastewater is the origin of about half of the total contamination in the catchment basin. Another major source of pollution is aquaculture, which contributes about one fifth on average during the year, but its significance increases substantially in summer (when the phosphorus balance is the most sensitive) and in some years, it achieves the same levels of phosphorus input as from wastewater. Agriculture contributes to the contamination of surface waters less importantly, with about one tenth of the total amount of pollution.

The shares of the pollution sources differ in the sub-basins of the Orlík Reservoir catchment, meaning that their specific features have to be considered.

At present, fishponds covering a total area of approx. 154 km^2 are managed for aquaculture in the Orlík Reservoir catchment basin. The study of phosphorus inflow and outflow (Hejzlar et al., 2010) identified the fishponds as a major source of phosphorus (contributing 58 t/year on average between 2007 and 2009, i.e., 3.8 kg of P per hectare of fishpond area per year). The cause is the so-called semi-intensive fish production, where the natural productivity of the fishponds is increased with the addition of fodder and fertiliser.

According to the results of the study of phosphorus inflow and outflow (Hejzlar et al., 2010), agriculture is a relatively small source of contamination. However, in some sub-basins (e.g., the Otava, Stropnice, and some side tributaries to the lake itself), the study identified significant local levels of contamination surpassing both municipal wastewater and aquaculture. Measures in agriculture are necessary in these areas for achieving an adequate reduction in the phosphorus input to the lake.

The phosphorus contamination from agricultural areas in the Orlík Reservoir basin is associated with two leading factors: (i) loss of soil particles from arable land during water erosion events, and (ii) apparently inappropriate handling of organic fertilisers, which can be washed off or leach into watercourses during hydrological events generating surface flow (intense precipitation, snowmelt, etc.).

1.2.3 Identification of the environmental goals

The model of phosphorus inflow and outflow indicates that the lake received 288 tonnes of phosphorus a year on average between 2007 and 2009. To prevent massive algal bloom in summer, the amount of P from the identified sources in the catchment basin has to be reduced by **136 tonnes a year** (to less than one half) (Hejzlar et al., 2010) compared to average 2007-2009 phosphorus inflows. This inflow decrease would mean a decrease in the total phosphorus concentration in Orlík from 100 μg/l to 50 μg/l. A lower reduction in the P loading will not have a sufficient effect on the water eutrophication consequences (Reynolds, 1992; Hejzlar et al., 2010) and the benefits from the phosphorus inflow lowering would therefore also be negligible (see below for more details).

The goal of the environmental measures is therefore to reduce the input of phosphorus into the lake below the critical load level, namely by 136 tonnes a year. Between 2007 and 2015, some of the water quality measures are being applied (they are expected to lower the phosphorus inflows by approximately 22 tonnes a year). For this reason, the goal of the CEA is to design a combination of applications of environmental measures (see below) that reduce the phosphorus input into the lake by 114 tonnes with the minimum possible costs.

1.2.4 Identification of measures

The measures can be divided into 3 basic categories based on the pollution source categories. The first are wastewater treatment plants and retention reservoirs; the second are measures to reduce phosphorus input from aquaculture (fisheries), the third are agricultural measures.

The selection of measures refers to the first stakeholder consultation process (described in detail within Deliverable 6.9). This process resulted in the following inputs to measure specification:

a) In the case of wastewater (pollution produced by human settlements): the construction and modernisation of treatment plants came out as the crucial measure. This general proposal was then split into a set of sub-measures according to a verification of situation in particular municipalities (somewhere only an intensification of wastewater treatment would be sufficient to reduce the P outflow, somewhere new sewerage would need to be built).

b) In the case of agricultural measures, grassing and a reduction in fertilizers were identified as important (again, stakeholder proposals were specified through a set of technical criteria – such as the spread of strips, slope of the land, etc. – for the purpose of economic evaluation).

c) In the case of fishery, the main proposal was to remove the historic burden of ponds (de-silting), other proposals referred to the problem of excessive use of fish feed and manure to increase production, especially in the case of small ponds where it is not restricted. Since there are no data regarding the historic burden problem (in which ponds, how much) and since there is an opinion controversy among fish producers and the academia regarding the role of historic burdens in current P emissions, we decided to focus on the fish feeding problem – two proposals based on a reduction of fish stock were proposed.

Besides the measures mentioned, stakeholders stressed real enforcement of existing legislation as a very important measure. For the purpose of the CEA analysis, however, there is a problem with quantification of the institutional changes.

Measures to reduce phosphorus loading from wastewaters

Due to the substantial share of wastewaters in the phosphorus sources in the Orlík catchment, an improvement of P removal efficiency in wastewater treatment plants (WWTP) can potentially be a very efficient measure to reduce the P input into the Orlík Reservoir. An approximate objective of this measure is to achieve a situation where most municipalities in the catchment remove 90% of P from their wastewater while currently they remove only approx. 60% on average. The 90% efficiency was chosen because the chemical precipitation process, which can be relatively easily completed in the activated sludge technologies (mostly used in WWTPs) and is cost-effective (Paul et al., 2001), has this efficiency.

The municipalities can currently be divided into the following categories by their methods of wastewater disposal and elimination of P:

A. Towns and villages with adequate sewerage and effective mechanical-biological wastewater treatment plants (MB-WWTP) using processes of increased phosphorus elimination (e.g., České Budějovice, Český Krumlov, Lipno, Frymburk, Horní Planá), achieving P (phosphorus) elimination above 90%, and small municipalities, which do not have good sewerage and WWTP but are situated off watercourses and do not discharge any wastewater. No applications of measures are required in these municipalities.

B. Towns and villages with adequate sewerage and MB-WWTP which do not achieve the 90% phosphorus elimination efficiency. The measure considered is expansion of the WWTP with a process of chemical dosing for simultaneous phosphorus precipitation with iron salts for permanent operation, guaranteeing the average 90% elimination efficiency.

C. Towns and villages with adequate sewerage but without appropriate WWTP. The measure considered is building a WWTP, including simultaneous phosphorus precipitation with iron salts for permanent operation.

D. Towns and villages with inadequate sewerage discharging excess quantities of ballast water, but with MB-WWTP with a P elimination efficiency < 90%. The measure considered is to build separate sewerage and completing the WWTP process with simultaneous phosphorus precipitation with iron salts for permanent operation.

E. Two possible alternative solutions are considered for municipalities without MB-WWTP and without adequate sewerage.

   The first option is process treatment, including building new separate sewerage and MB-WWTP, including simultaneous P precipitation. This is a very costly solution; this option is an economically viable solution only for municipalities with more than 100 inhabitants.

   The other option is to build a retention wetland while retaining the existing septic tank system for disposal of household sewage. This option is only viable for places with fewer than 100 inhabitants due to the required size of the wetland. In an effort to minimize the costs, the wetlands are considered for all the municipalities with fewer than 100 inhabitants.

Measures to reduce phosphorus loading from aquaculture

A reduction in the P export from fishponds cannot be achieved without changes to the fishery method, which means notably (i) reducing the fish stocking (thus production), (ii) setting the fodder and fertiliser doses to levels at best corresponding to the amount of phosphorus consumed in the fish production, that is, a zero balance. Alternatives to the current semi-intensive fish keeping include level-balance production and extensive fish keeping.

Description of the fish keeping methods:

- In the level-balance production, the fish production is set to 300 kg/ha/year, which is a level corresponding to a fish population that does not mobilise more phosphorus than what the fishpond is capable of retaining naturally. In other words, the fish population nullifies the natural retention capacity of the pond but adds no extra contamination.
- Extensive fish keeping makes use of no fodder or fertiliser and the fish stocking is such that the fish can utilise the natural productivity of the fishpond ecosystem (150 kg/ha/year on average). This option can achieve a reduction in the P export into the watercourses.

The above alternatives represent options for reducing the loads of phosphorus from aquaculture. The costs of these measures will have to equal the realised loss resulting from the reduced fish production converted for each water body based on the productive fishpond area.

The amount of phosphorus by which the export into the catchment basin will be reduced as a result of the alternative fish keeping methods will be (i) equal to the amount of phosphorus exported from the fishponds identified in the study of phosphorus inflow and outflow (Hejzlar et al., 2010) for the level-balance production method; and (ii) the net removal of phosphorus in the fish biomass produced.

Measures to reduce phosphorus loading from agriculture

The current general requirements on farming practice in the Czech Republic (GAEC) include a number of rules that reduce the leakage of phosphorus due to the factors mentioned below (which is one of the reasons for the relatively low agricultural contamination in the Orlík Reservoir basin). The CEA therefore only selects some measures that go beyond the scope of the general requirements, i.e.:

- Grassing over 20 m strips on either side along watercourses and reservoirs that are in contact with arable land, and then using these areas as permanent grassland without fertilisation.
- Grassing over all steep surfaces (> 7°) of arable land.
- Introducing no-tillage methods on arable land at gradients > 3°.
- Not fertilising sloping land (> 3°) with grassland using organic fertilisers.

1.2.5 Scope of the analysis

The catchment of the Orlík Reservoir consists of several sub-basins. Each of the sub-basins faces different conditions, therefore the analysis needs to consider the specific features of each of the sub-basins. The biophysical data acquired using the study of phosphorus inflow and outflow and the study of natural retention of the sub-basins are based on local measurements and take into account the specific local conditions. The model was expanded with possible applications of measures to reduce the phosphorus based on the biophysical data. The starting point of the calculation of costs of implementing the applications of measures was the knowledge of the current situation of the pollution sources and the assigned measures focused on phosphorus reduction. The study of phosphorus inflow and outflow therefore progressively collected information that was accompanied with economic data based on the costs of implementing the reduction applications of measures.

1.2.6 Assessment of the estimated effectiveness of various measures

The assessment and determination of the effectiveness of the various measures to decrease P export in surface waters is based on international literature, models and studies dealing with the effectiveness of measures in the area of point sources, agriculture and aquaculture. The effectiveness of wastewater treatment plants is derived from the concrete process equipment. The retention capacity of the wetlands is considered to be 50 kg of P per hectare per year, which corresponds to the results of retention wetlands (Fisher and Acreman, 2004). The determination of the effectiveness of fishery measures is based on the balance of P between inputs and outputs of fish keeping methods. For the agricultural measures, we mostly worked with catalogues of measures for improving the quality of surface waters in the CR (Cihlář et al., 2005) and the UK (Cuttle et al., 2007).

1.2.7 Cost estimates of the various measures: methods and data sources

The basic source of information for determining the costs of the measures **on the point sources** is the methodological document from Ministry of Agriculture (Ministerstvo zemědělství, 2010), which contains methodological instructions for approximate cost of the measure calculation. In addition, the cost estimates require the size of the population and the current condition of the point sources. This information is obtained in the study of phosphorus inflow and outflow (Hejzlar et al., 2010) . The calculation involves the costs of building (additional) or renovation of sewerage, wastewater treatment plants and retention wetlands, and the costs of introducing and operating the chemical dosing systems for simultaneous P precipitation with iron salts so that the measures achieve 90% phosphorus elimination efficiency and correspond to the current levels of wastewater contamination.

The costs of the measures in aquaculture equal the gross margin losses or increased profits from reduced or increased production converted to each water body based on the productive fishpond area.

The determination of the costs of the agricultural applications of measures is based on the data for each of the area type categories summed into basic units: water bodies under the Water Framework Directive. These data are part of the model database for the Orlík Reservoir catchment basin (Hejzlar et al., 2010), extended with data on the amounts of sloping arable land and grassland from the LPIS database and the estimates of the average width of existing grassy strips between arable land plots and watercourses. The amount of area affected by the agricultural applications of measures is multiplied by the investment and operating costs per hectare depending on the agricultural measure category.

1.2.8 Integration of the cost and effectiveness data

After assessing the effectiveness and costs of the implementation of the applications of measures, we determined the cost-effectiveness of the application of measures (calculating the abatement costs of the non-discharge of 1 tonne of phosphorus into the Orlík Reservoir). For this purpose, we calculated the annual costs for each application of a measure (out of the total costs) and then we divided the annual costs by the amount of phosphorus eliminated each year by the given measure application; the result is the "cost-effectiveness" ratio of each application in terms of the costs of 1 kg of phosphorus not discharged into Orlík Reservoir.

It must be stressed here that the natural phosphorus retention capacity of the corresponding water course was taken into account, so the cost-effectiveness of the measure application expresses the ratio of costs and the phosphorus not discharged **into the Orlík Reservoir**. Sometimes the pollution source is more than 150 km from the Orlík Reservoir and part of the phosphorus is caught naturally in the sub-catchment. For this reason, such a complex approach disadvantages the application of measures that are far from Orlík because part of the phosphorus that is removed would be naturally caught anyway even without their application.

1.2.9 Ranking of the applications of measures

After we calculated unit costs per 1 kg phosphorus not discharged into the Orlík Reservoir (see above), we could perform the final step of the analysis. The final step of the CEA was ranking of the applications of measures by their cost-effectiveness ratios from the cheapest ones to the most expensive ones. The CZK is used as the unit throughout the document.

The following scenario was defined for the CEA purposes. All the applications of measures (WWTP or retention wetlands, agricultural measures, fishponds) enter the analysis in the order of their cost effectiveness ratio (price per 1 kg of P not discharged into the Orlík Reservoir). With this procedure, we get a combination of nearly 2 thousand measure applications which if applied would **reach the goal in the cheapest possible way.**

2. Estimation of effectiveness and costs

2.1 Method for effectiveness estimates

The method for the effectiveness estimates is based on international literature, models and studies dealing with the effectiveness of measures in the area of point sources, agriculture and aquaculture.

Due to the substantial share of wastewater in the loading of phosphorus into surface waters, the objective of the applications of measures is to achieve a situation where most municipalities in the catchment basin remove 90% of the phosphorus from their wastewaters. The applications of measures proposed for the point sources are based on this requirement. The initial situation always corresponds to the current technical and process conditions. The measures applied increase the efficiency of P removal and the effectiveness of measures is evaluated from this increase. The retention capacity of the wetlands was considered to be 50 kg of P per hectare per year, which corresponds to the results from highly loaded retention wetlands (Fisher and Ackerman, 2004).

The effectiveness of the fishery measures depends on the fish keeping method chosen. Table 2 shows data on the phosphorus contamination production and size under the current semi-intensive fish keeping and the two alternative fish keeping methods. The P contamination and/or retention are calculated from the P balance between the amounts of P introduced into the ponds in fish stock, fodders, and fertilisers and P removed in the fish catch. In the current semi-intensive method of production, the amount of P in fodders (mainly cereals; P – 3.5 g/kg) and fertilisers (mainly stable manure; P – 1 g/kg) exceeds the amount of P in the fish biomass produced (mostly carp (*Cyprinus carpio*); P – 7.8 g/kg) by 1.7 kg/ha on average (Hejzlar et al., 2010). The levelled fish production method assumes lesser inputs but also approx. 50% lower yield to obtain no net surplus of P. The extensive method relies entirely on the natural productivity of fish ponds, which is approx. 150 kg/ha/yr of fish biomass in the upper River Vltava basin (Čítek et al., 1993) and corresponds to a net P removal of 1.2 kg/ha/yr.

Table 2: Characteristic production data on the current fish keeping method in fishponds in Orlík Reservoir catchment basin for 2007-2009 (semi-intensive) and two alternative methods (level-balance and extensive), reducing water phosphorus contamination

Fish keeping	Carp production, kg/ha	Fodder consumption, t/ha	Fertiliser consumption, t/ha	P balance, kg/ha
Semi-intensive	630	1.5	1.4	1.7
Balance	300	0.5	0.5	0.0
Extensive	150	0.0	0.0	-1.2

Source: Basin model of phosphorus inflow and outflow (Hejzlar et al., 2010)

The effectiveness of the agricultural applications of measures was determined expertly based on multiple sources, chiefly catalogues of measures for improving the quality of surface waters in the CR

(Cihlář et al., 2005) and the UK (Cuttle et al., 2007) and expert opinions of three national specialists in best agricultural management practices and water protection, which were reviewed in October 2012. Table 3 shows the values applied.

Table 3: Effectiveness of measures to reduce P loading to surface waters in Orlík Reservoir basin applied in CEA

Measure	Phosphorus retention efficiency (in %)
20 m grass strips between arable land and watercourses and reservoirs	45
Grass on sloping arable land at > 7°	70
No-tillage method on arable land at 3-7°	70
No organic fertilisers on sloping grassland (> 3°)	50

Source: Basin model of phosphorus inflow and outflow (Hejzlar et al., 2010)

The effect of the measures on arable land is not calculated independently of each other, but the measures are added in the order of decreasing cost-effectiveness (increasing unit abatement costs) of phosphorus elimination. The abatement costs increase in the following order: (i) 20 m grass strips, (ii) grass on sloping ground, (iii) no-tillage methods. For instance, we first calculate the reduction in the P export for grass strip application, the phosphorus export after expansion of the grass strips will be the base for reducing the P export in the subsequent calculation of the effect of grassing sloping land (instead of the original export before grass strips were applied). This combination yields 4 possible measures with different unit abatement costs and different phosphorus reduction. These measures enter the model by their unit costs of phosphorus reduction: the cheapest measure is entered in the model first, and if a more expensive measure enters the model then the first one is logically excluded and only the second one remains in the model. Naturally, the measures and the phosphorus reduction associated with them are considered in relation to the amount of area to which the measure is applied.

2.2 Cost estimates of measures

2.2.1 Point sources

The determination of the costs of point measures is based on the study of phosphorus inflow and outflow, which provides the required information on the existing methods of phosphorus elimination, amount of wastewater, population and existing export of P into watercourses. For registered municipal point sources, we calculated the average specific wastewater production per capita per day (the total amount of wastewater per year was divided by the population and the number of days in a year), and the average biochemical oxygen demand using the dilution method in the course of five days (BOD_5) in the wastewater. In addition, we determined the total theoretical production of P based on the population and the specific P production per capita (1.7 g of P/capita/day).

From the existing export of P, we calculated the export of P with 90% P elimination efficiency. The difference between the existing export of P and that with 90% efficiency represents the potential phosphorus reduction using the measure in question. The calculation of the costs of the applications of measures to increase the efficiency of P elimination from wastewater to 90% was made depending on the source type and size:

A. No applications of measures are considered for towns and villages with WWTP with current P elimination efficiency of 90%, therefore the costs are zero.

B. For towns and villages with adequate sewerage[1] and a wastewater treatment plant with P elimination efficiency below 90%[2], we propose the addition of a process for simultaneous P precipitation as the measure. The costs were calculated based on estimates in the literature (Stara, 2010; Pöyry, 2012) as the sum of the investment costs plus operating costs. The investment costs of simultaneous P precipitation are CZK 100/capita, which makes CZK 7.3/capita/year with discounting (20 years, 4% interest). The operating costs are CZK 25/capita/year, corresponding to an average wastewater production of 200 l/capita/day.

C. For municipalities with adequate sewerage but without an adequate WWTP, the costs of completing the WWTP are considered. The calculation is based on the population and the rated price indicator for WWTP related to the equivalent population as given by the 2010 Ministry of Agriculture methodological instruction.

D. For towns and villages with inadequate sewerage discharging excess quantities of ballast water, but with an MB-WWTP with a P elimination efficiency below 90%, we propose building separate sewerage and expanding the WWTP processes with chemical dosage for permanent simultaneous P precipitation as the measure. The costs of the sewerage are based on the length of the sewerage, calculated from the equivalent population connected and the size of the municipality. The rated sewer length is then reflected in the investment costs, calculated from the standardised costs of sewerage construction quoted in the 2010 Ministry of Agriculture methodological instruction[3]. Table 4 shows the resulting discounted figures (20 years with 4% interest). The calculation of the costs of simultaneous precipitation is described in B above.

E. The measures for sources without wastewater treatment plants are proposed as two options. The first is process treatment with building new separate sewerage and WWTP with P precipitation. The costs are calculated as the sum of the sewerage costs and the WWTP costs. The calculation components are described in C above for the plant and D for the sewerage.[4]

   The other option is adding retention wetlands to the current condition. They are water reservoirs half embedded and half leveed, with a shallow and a deep part, with exclusively a top discharge and water retention time of at least 20 days. The total investment costs are about CZK 1 million per hectare. The retention efficiency of the wetlands is assumed to be 50 kg of P per hectare per year. Converting this to the equivalent population and discounting (20 years, 4% interest), the costs are CZK 820/equivalent inhabitant/year.

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[1] Adequate sewerage refers to sewerage where the ratio of ballast water and sewage does not exceed 2:1; this is established, e.g., from the average specific water consumption being below 300 l/capita/day and the average BOD_5 concentration at the WWTP inlet being more than 200 mg/l.

[2] The majority of municipalities with a population above 2000 meet this requirement.

[3] The standardised costs quoted by the methodological instruction are CZK 6 thousand per metre of sewer, or CZK 438 per metre per year with discounting (20 years, 4% interest).

[4] As already noted in 1.5.1, this is a very costly and thus rather ineffective solution; this option is only a reasonable solution for municipalities with over 100 inhabitants.

Table 4: Rated sewer length and investment costs (20 years) of building new separate sewerage in municipalities of different sizes

Municipality size (equivalent population)	Rated sewer length per equivalent inhabitant (metres)	Investment costs of sewerage (CZK/equivalent inhabitant/year)
<100	40	17,500
101-200	20	8,800
200-300	18	7,900
300-500	15	6,600
500-1,000	8	3,500
>1,000	5	2,200

Source: MZe ČR, 2010

2.2.2 Fishery measures

The cost determination is based on the loss (profit decrease) from reduced production converted to the water bodies depending on the fishpond production area. The calculation is based on typical fish prices and the most common fodder and fertilisers (i.e., prices: carp: CZK 65/kg, fodder cereal: CZK 3,800/tonne, dung: CZK 200/tonne; P content: carp: 7.8 g/kg, fodder cereal: 3.5 g/kg, dung: 1 g/kg). Table 5 shows the calculation results.

2.2.3 Agricultural measures

The cost determination for the agricultural measures is based on the data for the sub-categories of areas summarised in the basic units. The size of the area affected by the agricultural applications of measures is multiplied by the investment and operating costs per hectare, depending on the agricultural measure category. As mentioned above, the investment costs were calculated expertly based on relevant sources, chiefly catalogues of measures for improving the quality of surface waters in the CR (Cihlář et al., 2005) and the UK (Cuttle et al., 2007). Again, discounting was applied (20 years, 4% interest). Table 6 shows the resulting costs.

Table 5: Characteristic production data on the current fish keeping method in fishponds in Orlík Reservoir catchment basin for 2007-2009 (semi-intensive) and two alternative methods (level-balance and extensive), reducing water phosphorus contamination

Fish keeping	Carp product-ion, kg/ha	Fodder consumpt-ion, t/ha	Fertiliser consumpt-ion, t/ha	P balance, kg/ha	Costs of fodder and fertiliser, CZK thousand/ha	Carp sales receipts, CZK thousand/ ha	Profit, CZK thousand /ha	Loss from reduced production, CZK thousand/ha
Semi-intensive	630	1.5	1.4	1.7	6.0	41.0	35.0	-
Balance	300	0.5	0.5	0.0	2.1	19.5	17.4	17.5
Extensive	150	0.0	0.0	-1.2	0.0	9.8	9.8	25.2

Source: Basin model of phosphorus inflow and outflow (Hejzlar et al., 2010)

Table 6: Costs of agricultural measures to reduce P export to surface waters in Orlík Reservoir basin

Measure	Phosphorus retention efficiency, %	Investment costs		Operating costs, CZK thousand /ha/year
		Total, CZK thousand /ha	Discounted, CZK thousand /ha/year	
20 m grass strips between arable land and watercourses and reservoirs	45	10	0.73	5
Grass on sloping arable land at > 7°	70	10	0.73	5
No-tillage method on arable land at 3-7°	70	6	0.44	6
No organic fertilisers on sloping grassland (> 3°)	50	0	0	5

Source: Basin model of phosphorus inflow and outflow (Hejzlar et al., 2010)

3. Results: cost-effectiveness analysis

As mentioned, some of the water quality measures are being applied between 2007 and 2015. Some of the measures have already been completed, others are being implemented, and yet others have not commenced this far but are assumed to start before 2015. There are 179 measures in total. A large part of the measures are already being implemented, and no more than ¼ of all the measures will continue until 2015. Unfortunately, we do not have data for all these measures that would be as good as those available for the measures assumed further in the CEA. We only have data on the expected costs of these measures, and data on the actual costs of those that have been completed. Data on the quantity of phosphorus intercepted are not available. Since this information is important for calculating the remaining reduction target at which the CEA measures will be aimed, an estimate of the phosphorus intercepted was made using the balancing model of the Biological Centre of the Academy of Sciences in České Budějovice. It was estimated from the model that the phosphorus export will be reduced by no more than 22 tonnes after the implementation of all the possible measures by 2015, which is approx. 20% of the total reduction goal (of 136 tonnes). Local changes in the water quality can be expected as a result of a moderate pollution reduction, namely in the Otava arm of Orlík, downstream of the discharge of the Lomnice. This local water quality improvement is also reflected in the size of the benefits calculated in the disproportionality analysis.

The annual costs of implementation of all the measures (i.e., the sum of the actual costs of measures already completed and projected costs of measures being implemented or planned until 2015), calculated using the same methodology as for the theoretical measures in the CEA, are CZK 465 mil. (EUR 17 mil.).

The table below shows the structure of measures implemented in 2007–2015, broken down into point source, fishery and agricultural measures.

Table 7: Structure of application of water quality measures in 2007–2015

Point sources	421	CZK mil./year	(90.5%)
Agriculture	7	CZK mil./year	(1.5%)
Fisheries	37	CZK mil./year	(8.0%)
Total	**465**	**CZK mil./year**	**(100.0%)**

Source: Own analysis

The remaining part of Chapter 3 presents the results of the cost-effectiveness analysis. Our objective was to use the cost-effectiveness analysis approach to calculate the lowest possible costs of reducing the phosphorus inflow to the required value, i.e., by 114 tonnes.

3.1 Effectiveness

The measures were assessed in accordance with the above economically tidy scenario. All the applications of measures (WWTP or retention wetlands, agricultural measures, fishponds) enter the analysis in the order of their cost-effectiveness (price/kg of P reduction).

When ranking the applications of measures by their cost-effectiveness, we progressively added up the total P production. In order to reduce the P production by the required 114 tonnes, at least 1,610 applications of measures have to be implemented with the total annual cost of CZK mil. 602 (EUR 22 mil./year). The detailed structure by category is shown in Table 8.

Table 8: Most cost-effective applications of measures to reduce phosphorus by 114 tonnes/year

Category	Measure type	No. of applications of measures	Phosphorus eliminated (tonnes)	Annual costs of measures (CZK million)
Point measures	Simultaneous P precipitation with iron salts	56	9.6	3
	Building WWTP incl. simultaneous P precipitation	11	0.6	8
	Building separate sewerage and adding simultaneous P precipitation to WWTP	52	8.6	126
	Building sewerage and WWTP incl. simultaneous P precipitation	37	5.0	111
	Building retention wetlands	1,122	10.2	19
Total point measures		**1,278**	**33.9**	**266**
Agricultural measures	Grassing 20 m strips either side	122	5.4	10
	Grassing all sloping areas	0	0	0
	No-tillage methods on arable land with gradients > 3°	51	2.0	10
	No organic fertilisers on sloping land (> 3°) with grass	60	3.6	7
Total agricultural		**233**	**11.0**	**27**
Fishery measures	Level-balance production	19	21.2	47
	Extensive production	80	47.9	263
Total fishery		**99**	**69.1**	**310**
Total		**1,610**	**114.0**	**602**

Source: Own analysis

The cost of eliminating 1 kg of P differs across the measure categories. As documented by Table 9, the retention reservoirs are the least costly and the WWTP are the most costly. The applications of agricultural measures and fishpond measures are approximately identically costly.

Table 9: Average costs (per kg of P) of measures

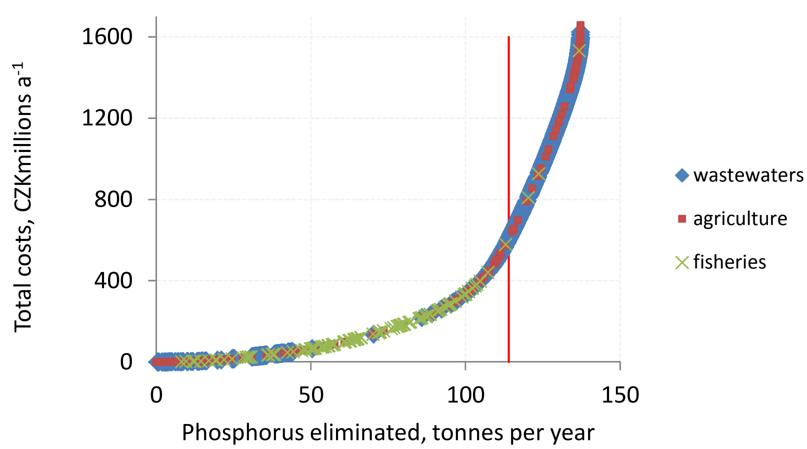
Category	Measure type	Average costs (per kg of P)
Point measures	**Average of all applications of measures in category**	**7,843**
	Retention wetlands	1,831
	Wastewater treatment plants incl. sewerage and simultaneous precipitation	22,305
Agricultural measures	**Average of all applications of measures in category**	**2,425**
Fishery measures	**Average of all applications of measures in category**	**4,485**

Source: Own analysis

3.2 Costs

The chart in Figure 1 indicates the growing abatement costs for P input to the lake with the progressive implementation of additional applications of measures. The costs increase because we first assume the implementation of the most cost-effective applications of measures; however, they do not suffice to reduce the P input by the required 114 tonnes. That is why additional, more costly applications of measures are implemented afterwards until the threshold of 114 tonnes is reached. The measure categories are colour-coded. Each coloured point represents one application of measure.

Figure 1: Costs of applications of measures reducing phosphorus input to Orlík Reservoir



Source: Own analysis

The reduction of the P input by 114 tonnes therefore requires (see Table 10 below):

- implementation of almost all potential fishery measures (namely, utilisation of 96% of possible applications in this measure group);
- reduction of pollution from point sources by 71% utilisation of this group;
- reduction of phosphorus losses from agriculture by 66% utilisation of this group.

Table 10: Contribution to the overall goal by measure type

Category	Maximum potential phosphorus eliminated (in tonnes)	Phosphorus eliminated by effectiveness (in tonnes)	Percentage of utilisation of measure type
Point source applications	55.9	33.9	71%
Applications of agricultural measures	11.5	11.0	66%
Applications of fishery measures	69.9	69.1	96%
Total	**137.3**	**114.0**	**71%**

Source: Own analysis

3.3 Summary and discussion of CEA

Within the CEA, we searched for a cost-effective way to meet the water requirements of the Water Framework Directive (WFD) in the basin of the Orlík Reservoir. Following the analysis of primary sources of phosphorus, appropriate applications of measures in the fields of municipal wastewater, agriculture and fisheries were suggested. The main result of the CEA is that in order to decrease the phosphorus inflow into the Orlík Reservoir by 114 tonnes per year, **1,610** measures **have to be implemented**, with the total **annual costs of** CZK 602 million (**EUR 23 million**).

The highest share of costs in the CEA scenario pertains to applications of measures in the **fishery area.** The removal of **69 tonnes** of phosphorus per year would require CZK 310 million (**EUR 11.5 million**). A transition from the current intensive fishing to less environmentally damaging (extensive or balanced) fishing would lead to a significant decrease in the fish farmers' income. The removal of 34 tonnes of phosphorus per year at point sources would require CZK 266 million (EUR 9.9 million) (44% of the costs). The costs of applications of agricultural measures are less important in comparison with the two previously mentioned categories.

The implementation of measures at point sources would require large investments that may be beyond what the municipalities can afford (especially the smaller ones). Regarding the pond owners, no voluntary reduction of fish production can be expected without compensations or a stricter regulatory framework because any reduction means loss of profit for the pond owners (which also became evident at the stakeholders' workshop in Písek in February 2013).

PART II: Disproportionality Analysis

4. Application of the methodological approach

The following chapter introduces the disproportionality analysis (hereinafter the DA) to the reader. In agreement with the methodological guideline to the DA, two time horizons for the analysis were defined. The first one is the period 2007–2015, where the benefits are derived from the water quality changes caused by the application of the water quality measures that were or will be applied by the end of 2015 (see Chapter 1: General CEA Approach). The second time horizon is 2016–2035, which corresponds to the realisation of the cost-effective scenario. In this scenario, we suggest that all the water quality measures will be applied and cause the expected water quality changes and corresponding benefits starting from 2016. This is a very strong assumption, but it is the most demonstrative scenario that strives to demonstrate whether the application of the cost effectiveness scenario to improve water quality will bring the benefits that justify the very high costs of these water quality improvement measures.

The results of the analysis are put into the context of the second stakeholder engagement process – the workshop in Písek held in February 2013 (for more detailed information, see the separate project report "Second stakeholder engagement process in the Vltava catchment, Czech Republic – disproportionality analysis and flagging the wider benefits" developed by Slavíková et al., 2013). The workshop was aimed at flagging the wider benefits and gathering qualitative data through the stakeholders' views. The initial step to the disproportionality analysis was a literature review, which was followed by an economic analysis and additional consultations with experts. The methods used followed the methodological approach to disproportionality analysis developed by Martin-Ortega and Skuras within WP6 (Martin-Ortega and Skuras, 2012).

The results of the analysis suggest that the application of water quality measures is highly controversial when it is viewed only from the economic efficiency point of view.

4.1 Justification of disproportionality analysis

The performance of disproportionality analysis is important for several reasons. Article 4 of the WFD allows derogation and exemptions for environmental objectives in the case of disproportionately high costs to achieve environmental targets. Derogation is mentioned in two basic cases. It can either be an extended deadline for achieving a "good ecological status" (GES) or can set less stringent environmental goals (European Communities, 2009). Extension of deadline applies especially to those territories for which costs are disproportionate to achieve the deadline. In case that the total costs of achieving a GES are greater than the expected benefits resulting from achieving environmental goals, it is possible to reduce the environmental target.

Within the REFRESH project, the disproportionality analysis proved to be necessary. In the disproportionality analysis, we focused on the main benefit of clean water: the recreational benefit. First, we examined the potential benefits and the recipients, and then we worked on the definition of the territory covered by these benefits. To meet both of these tasks, it was necessary to use a wide range of expert consultations. For determining the amount of benefits, we used the data on visitation rates of the Orlík Reservoir (from different sources; see respective subchapter for details) and we interviewed several camp providers and tourism experts for the future visitation outlook. The estimation of benefits was made using a literature review and a benefit transfer.

Another important issue is the disproportion between the costs and the benefits: the cost bearers and beneficiaries. Following the CEA, where we investigated who is supposed to be the main cost bearers and what costs they are supposed to pay in absolute figures, the disproportionality analysis was interested in who the main beneficiaries are and how the beneficiaries correspond to the cost bearers.

4.2 Specification of benefits included in the analysis and methodological framework adopted for benefit estimation

Taking into consideration the geographical location and the size of the Orlík catchment, it is straightforward that many benefits are lost or significantly reduced by the strong occurrence of cyanobacteria in the reservoir.

We classified them as follows:

1) loss of recreational benefits
   a. reduced or disabled swimming opportunities
   b. influence on sport fishing/angling
   c. yachting
   d. camping in the campsites
      (people not coming or having lower utility from their recreation)
   e. lower utility for people who have holiday homes near the lake
2) Lower price of the holiday homes by the reservoir
3) The defensive and averting expenditures of individuals (Czech citizens travelling far away to visit different localities)
4) Impacts on human health
5) Loss of profit for local entrepreneurs providing accommodation
6) Loss of income for municipalities due to the decrease in entrepreneurs' profit

For the disproportionality analysis, it is necessary to calculate the overall loss of the benefits caused by eutrophic water. If measures to improve water are applied, the water quality is improved and the loss of benefits is eliminated.

Our research further focuses solely on the recreational benefits. Other benefits are included in the analysis in the form of the variable "percentage of benefits included" (see below for details). The reason is that the experience from a similar case analysis on Lake Mácha[5] (Vojáček and Pecáková 2010) (see comments below) has showed that loss of recreational benefits is a dominant factor when analysing loss of benefits due to eutrophic water.

For this reason, we analyse the loss of recreational benefits in detail with a focus on the activities that are the most influenced by the poor water quality: (i) swimming in the lake (local residents, city visitors, camp visitors, holiday home owners, etc.), (ii) camping in the campsites, which is influenced the most by the possibilities of waterside recreation activities, and (iii) summer recreation of people who have holiday homes near the reservoir and have lower utility because of the limited swimming possibilities in the lake.

[5] In the Lake Mácha study the results were discussed on the stakeholder seminar. It was not done on purpose. The reason was that the local authorities and the not-for-profit organisation involved in the water quality issues noticed the study on internet and ask the authors to present the results and discuss them at the common seminar. At the seminar main stakeholders were present and the results were accepted.

On the other hand, the Orlík Reservoir is less crowded due to the lower visitation rates, which can be a source of utility for residents and possibly also for the holiday home owners. We did not try to calculate this effect.

We consider the two remaining recreational benefits (that is, sport fishing and yachting) to be of peripheral importance. The reason in the case of the **sport fishing** is that the effect of clean water on the utility of anglers is unclear. We suppose two effects: lower water eutrophication probably means lower fish catch; secondly, clear water can bring higher pleasure and thus utility to anglers, therefore it is a question whether water quality improvement causes benefits or costs to anglers. Based on the estimates of a 2010 study of the Czech Fishing Union[6], 16,000 anglers visited the reservoir in the course of 2009, making 155,000 visits. However, an empirical study as evidence of anglers' utility changes would be needed to calculate the benefit changes. The utility of sport **yachting** can be higher in clean water conditions due to the increase in the aesthetical function. There are several yacht clubs on the reservoir. The quantification of the benefits would again require an empirical study among the yacht providers, owners and users. Anyway, there is only a very limited number of yacht owners and providers compared to the thousands of other recreationists and therefore we suppose that their omission does not influence the results of the analysis.

To summarise: possible benefits not counted in the analysis that can be gained when water quality increases are in the following areas:

1) Sport fishing/angling (may also be costs – see above)
2) Sport yachting
3) Increased prices of the holiday homes by the reservoir
4) Increased profit for local entrepreneurs providing accommodation
5) Increased income for municipalities due to the increase in the entrepreneurs' profit

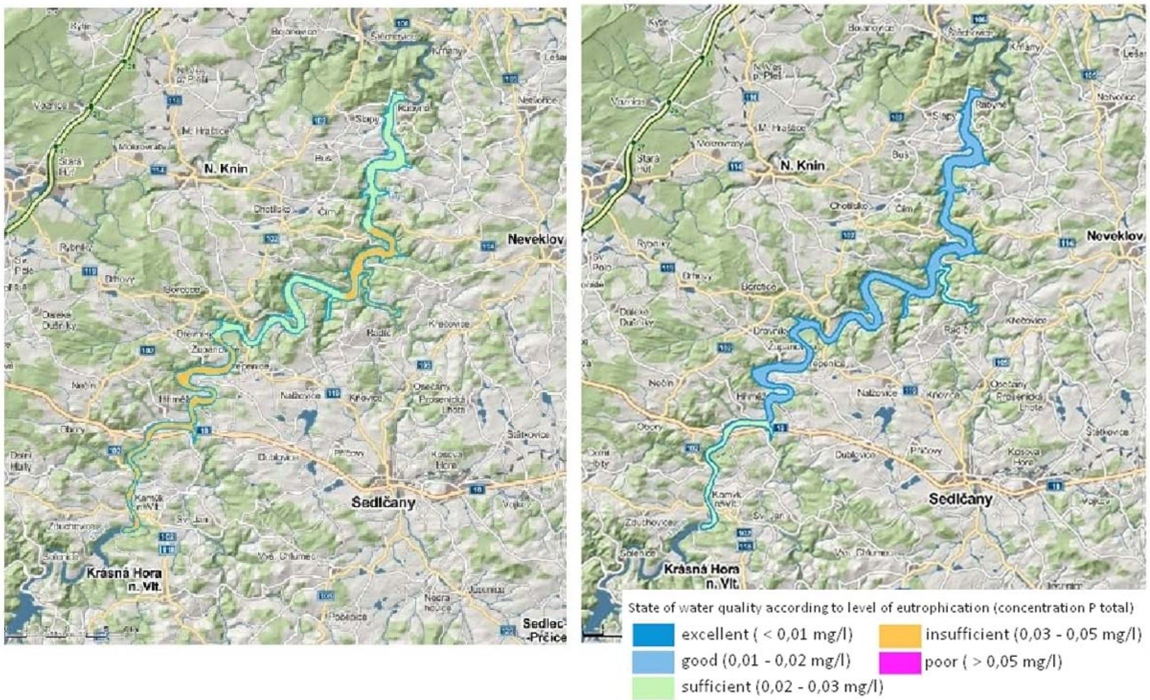
In fact, one significant benefit may have been completely omitted. Downstream from the Orlík Reservoir is the Slapy Reservoir, of approximately 2/3 of the size of the Orlík Reservoir. The Slapy Reservoir has a slightly better water quality compared to Orlík, but undoubtedly significant benefits would be gained if the water quality improved. The water quality measures to clean the Orlík Reservoir would have a demonstrably positive effect on the water quality in the Slapy Reservoir. The benefits gained due to the Slapy Reservoir are important in the respect that the Slapy Reservoir is not far from Prague. The Slapy Reservoir is only 27 km far from the Prague 5 district (i.e., approximately half-an-hour drive by car) and only 37 km from the city centre (41-minute journey[7]). Prague citizens visit the Slapy Reservoir for swimming even only for one day. However, the swimming possibilities at the Slapy Reservoir are significantly restricted by the poor water quality as demonstrated by the map in Figure 2.

The analysis of Slapy Reservoir benefits exceeds the scope of this analysis, but we can suppose huge benefits thanks to the proximity of Prague. The total benefits would likely increase in the case of all the applications of measures referred to in the CEA.

[6] "Orlík Reservoir usage from the point of view of the fishing territory user" (2010), Czech Fishing Union, elaborated for the conference "Revitalisation of the Orlík Reservoir".

[7] See the website www.mapy.cz for the distance demonstration:
http://www.mapy.cz/#!x=14.602989&y=49.953498&z=9&t=r&rc=14.434141_50.083549_14.396118_49.815308&rl=Praha%2C%20okres%20Hlavn%C3%AD%20m%C4%9Bsto%20Praha_Slapy%2C%20okres%20Praha-z%C3%A1pad&rp=%7B%22criterion%22%3A%22fast%22%7D

Figure 2: Current state of water quality in Slapy Reservoir according to eutrophication indicators in 2006–2011 (left) and in the future case of CEA scenario application (right)



Regarding all the benefits excluded from the analysis, we adopted the scenario approach in the DA analysis. We created a variable called "percentage of benefits included" ranging from 50% to 90%. This variable makes provision for the benefits omitted, for example the value in the "pessimistic scenario" is 90% which means that 90% of the total benefits are covered by the recreational benefits. The optimistic scenario value is only 50%, meaning that we covered only 50% of the total benefits by the recreational benefits.

4.3 Identification of cost bearers and beneficiaries

The beneficiaries are the same for both the scenarios and, as described in the previous subchapter, beneficiaries are holders of the water-related benefits arising from the water quality improvement – tourism entrepreneurs and the public represent the main groups in focus. They can be described as follows:

- Providers of camping sites, hotels, hostels and other types of commercial accommodation
- Providers of other leisure-time services, such as restaurants, yacht docks, etc.
- Municipalities (via extra revenues to municipal budgets, e.g. through the recreation fee per night paid in the price of accommodation, through entrepreneurs' income tax)
- Owners of private holiday homes, individual anglers, local people spending leisure time at Orlík (informal recreation)

Detailed discussion of the benefits is made in Chapters 5.1 and 5.2.

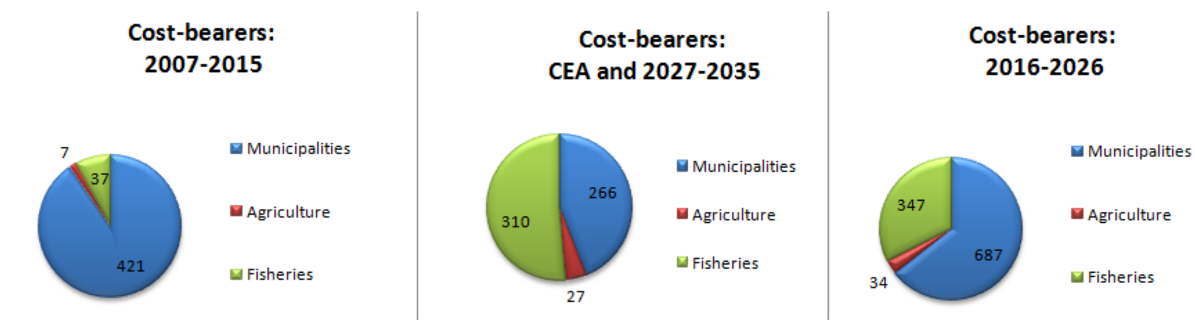
The cost bearers differ in the 2007–2015 and the CEA scenarios. As it is shown in the following table (Table 11) and the charts in Figure 3, the main cost bearers in the 2007–2015 scenario are municipalities followed by fisheries (mostly pond revitalisations), while the main cost bearers in the CEA scenario will be (when the cost effectiveness scenario is realised) fisheries followed by municipalities. Agriculture is marginal in both scenarios. The costs of the 2016–2035 scenario consist of the costs already realised in the 2007–2015 scenario and, starting from 2016, also the costs of the application of the water quality measures of the cost-effectiveness scenario. The 2007–2015 costs disappear from the 2016–2035 scenario in 2027 as the 20-year lifespan is completed (2007–2026).

Table 11: The cost bearers in the 2007–2015, CEA and 2016–2035 scenarios (CZK million/year)

Time horizons	2007–2015	CEA	2016–2035	
			2016-2026	2027-2035
Point sources	421 (90%)	266 (44%)	687 (64%)	266 (44%)
Agriculture	7 (2%)	27 (5%)	34 (3%)	27 (5%)
Fisheries	37 (8%)	310 (51%)	347 (33%)	310 (51%)
Total	**465 (100%)**	**602 (100%)**	**1,067 (100%)**	**602 (100%)**

Source: Own analysis

Figure 3: The cost bearers in 2007–2015, CEA and 2016–2035 scenarios



Source: Own analysis

4.4 Identification of spatial and temporal scales for the disproportionality analysis

The WFD itself does not specify in any way on what spatial scale the disproportionality analysis has to be carried out. It is recommended within the Refresh Project (Deliverable 6.3) that the sub-catchment approach be used. This is the level at which all local specificities are not lost. In the case of the Orlík catchment, we have restricted the area to the immediate surroundings of the reservoir. The reason is that it is the most logical and natural area that would be influenced by the assumed water quality changes. We also suppose that there is an acceptable level of uncertainty about the possible effects and benefits, which grows when extending the analysis beyond the immediate surroundings of the reservoir. For example, we suppose that the water quality improvement in Orlík will cause an increase in the visitation rate at the lake attracting people searching for waterside recreation. We assume firstly a utility increase to be by the people coming regardless of the water quality and secondly, more people coming mean higher utility. However, in the case of calculating the benefits from water quality improvement also in tributaries, we would have to model the potential visitors' behaviour more comprehensively, which would be accompanied with even more uncertainty and a significant increase in the data requirements (e.g., there are hundreds of ponds in the Orlík catchment that are used for swimming during the summer season; how would the benefits at these ponds change; would people visit these ponds or the Orlík Reservoir if water quality increased in both, etc.). For these reasons, possible benefits from other parts of the catchment were not included in the disproportionality analysis. The quantification also did not take into account localities downstream from the Orlík Reservoir such as the Slapy Reservoir mentioned above. Within the specified area, we also described benefits that could not be quantified but were identified as important during either the workshop or the expert consultations. For all these reasons, we consider the benefits for the lower bound of the estimates in most of the scenarios.

The temporal scale of the analysis has already been described (see above). In agreement with the methodological guideline to the DA, two time horizons for the analysis were defined. The first is the period 2007–2015, where the benefits are derived from the water quality changes caused by the application of the water quality measures that were or will be applied by the end of 2015 (see Chapter 1: General CEA Approach). The second time horizon is 2016–2035, which corresponds to the realisation of the cost-effective scenario. In this scenario, we suggest that all the water quality measures will be applied and cause the expected water quality changes and corresponding benefits starting from 2016. In reality, it is not clear whether and what applications of measures will have taken place and when the applications of measures will be implemented. It is not possible to estimate how quickly the benefits will accrue. As we mentioned in the previous section, the current River Basin Management Plan does not contain any concrete applications of measures.

4.5 Data sources and methods

Several sources of data are used in the benefit analysis part. After the literature review was completed, one particular Czech study was selected for benefit transfer. Several data sources were used for the data on the Orlík Reservoir visitation rates, specifically (i) the Czech Statistical Office data were used for the number of nights spent in larger accommodation facilities. The CSO publishes data for each municipality with more than three accommodation facilities. It includes mostly larger municipalities with campsites and boarding houses. We gathered data on 9 villages and 4 towns out of the total of 30 villages and 9 towns. The estimation of the visitation rates of villages with fewer accommodation facilities used their public municipal budget figures[8]. This income has to be published as part of each municipality's budget. Some of the villages do not have any significant accommodation capacities, which is why data about nights spent were not collected from them. In one case, we were not able to obtain the required data in spite of significant capacity. Overall, we estimate that approximately 90% of the total visitation rate is covered in the analysis. After we obtained the data for the **whole year**, we had to estimate the summer season data that are relevant for the waterside recreation. Therefore, we consider only sunny days in the period from June to September as possible opportunities to go bathing. The accommodation providers gave us the estimates of the share of the summer season visitation to the total visitation: 70% of the total number of nights spent in towns in our area fall into the period between June and September. This percentage is even higher in the villages, in some cases up to 95%. To estimate the number of recreations during summer we use a weight mean of 85%.

Recreational buildings were counted in the catchment area. Cadastral maps were used for this purpose.[9] Local authority representatives' estimates were used for the estimation of the number of nights spent by these visitors as the only available data. According to these estimates, there are, on average, 2 adults for the period of 10 weekends in each cottage, bungalow or houseboat during the summer season.[10] It gives us 40 nights spent in each recreational building per summer season.

The number of days spent by local residents on the beaches was estimated based on Czech Statistical Office data. There are 9 towns and 30 villages with 62.5 thousand inhabitants in the catchment area.

[8] A spa fee has to be paid in the Czech Republic for each person who comes to a municipality and spends a night in an accommodation facility in its territory.

[9] Cadastral maps are publicly available at: http://www.cuzk.cz/

[10] The estimation corresponds with estimations by other professionals. It is necessary to consider that a whole family (4 or more members) often visits one recreational building. Some private recreational buildings are rented or people spend their whole retirement there.

We assumed that a certain share of the inhabitants use the Orlík Reservoir for their summer waterside recreation. Given the large amount of natural substitutes for the lake, we estimate that every tenth person spends at least two days at the Orlík Reservoir in the summer season.

For the visitation rate projections, we interviewed all the main campsite providers in the catchment area in the course of July 2013.

4.5.1 Literature review

In order to estimate the changes in recreational benefits from the water quality improvement, it is necessary to know how people would value these water quality changes. Methodological options for the value elicitation include either an empirical study in the target population or adopting values from a suitable different study, i.e., benefit transfer.

A benefit transfer was made in order to calculate possible benefits from water quality measures. For this reason, we spent some time reviewing studies and searching for studies which would best reflect the situation being analysed in the Orlík Reservoir case, i.e., similar environmental changes, target population, water type, region and affluence of the country's economy. After all our effort (more than 30 different studies were reviewed), we found the study made at Lake Mácha in the Czech Republic in 2007 called "Analysis of the Economic Impacts of Water Eutrophication: Lake Mácha Case" (Vojáček and Pecáková, 2010) to be the most appropriate and useful; it deals with the economic impacts of water quality changes (more specifically water eutrophication).

In the Lake Mácha study the benefits are calculated using **the visitation rate** (number of person-days spent by visitors by the lake doing water-related activities). Therefore, we calculated as precisely as possible the number of days spent on the Orlík Reservoir beaches by the above listed users (residents, camp visitors, holiday home visitors, visitors from local towns and villages) in both the scenarios analysed: 2007–2015 and 2016–2035. To assess the number of person-days, we had to make some assumptions about the visitors' behaviour regarding their recreation at the reservoir and in its surroundings (e.g., the frequency of visits to the reservoir by visitors of surrounding villages etc.). A detailed analysis of the numbers of visits is made in the next chapters. The following sub-chapter brings a detailed description of the benefit transfer study (the Lake Mácha study) and its methodology.

Lake Mácha – Study description

Lake Mácha is one of the surface water bathing sites in the Czech Republic which have suffered from low water quality in recent years. It is situated in the Liberec Region, approx. 100 km north of Prague. Its size is approximately 305 hectares. It lies in a tourist district and is crucial for the tourism in the district. The poor water quality of Lake Mácha is caused by high phosphorus content in the water (water eutrophication), which has caused significant occurrence of cyanobacteria. The problem of eutrophication of the lake water escalated in 2004, when the swimming was banned and the beaches closed already in June. Because of the bathing ban, the revenues from tourism decreased and caused economic problems to many businesses in the tourist-oriented region (Doksy, 2007). As is obvious, the problems and the purposes of Lake Mácha are strikingly similar to those of the Orlík Reservoir. The methodology and approach used in the case of Lake Mácha can also be applied to that of the Orlík Reservoir. Nevertheless, comparing Lake Mácha to the Orlík Reservoir, significant differences can be found. Probably the main difference is the historical context. Lake Mácha was used a lot for summer waterside recreation in the socialist period. Sometimes it was called the "Czech Sea". Besides, Lake Mácha is very popular for many happenings during the summer, when especially young people visit the lake for this reason: they use the lake during the day and enjoy the night life after that. It is unique in the economic sense and an adequate substitute could hardly be found in the Czech Republic. Especially for the reason of its low substitutability, we are convinced that the WTP for the water quality at Lake Mácha is too high for the Orlík Reservoir case. Therefore, we created a variable in the scenario approach applied in the DA called "WTP (multiple of value)" ranging from 0.7 to 3.2. This variable makes provision for the uncertainty about the size of the individual benefits arising from water quality improvement. For example, the value in the "pessimistic scenario" is 0.7, meaning that the WTP at the Orlík Reservoir is only 0.7 of the Lake Mácha WTP.

A choice experiment study was carried out at Lake Mácha in 2007 to assess the potential benefits from water quality improvement. identified Summer vacationists were identified as the most important group of potential beneficiaries. The research therefore focused on the beach visitors. After several preliminary survey stages, the attributes relevant to summer waterside recreation were discovered: (i) beach crowdedness, (ii) water quality, (iii) beach equipment, (iv) entrance fee. The water attribute is relevant for the purpose of this analysis and the benefit transfer issue. It is important to understand in detail what the particular water attribute levels describe.

Given the motivation of the research at Lake Mácha – water economics research – the water attribute was the most important. It was cautiously balanced so that it described the required water quality changes in a way understandable to visitors unfamiliar with the water quality issue. We wanted to capture possible benefits arising from two possible water quality changes:

1) firstly, a water quality improvement by which the massive cyanobacteria would be eliminated;
2) secondly, water that does not suffer from cyanobacteria and even has a higher in-depth visibility. For this reason, we had three levels of the water quality attribute (Table 12).

Table 12: Water quality attribute description

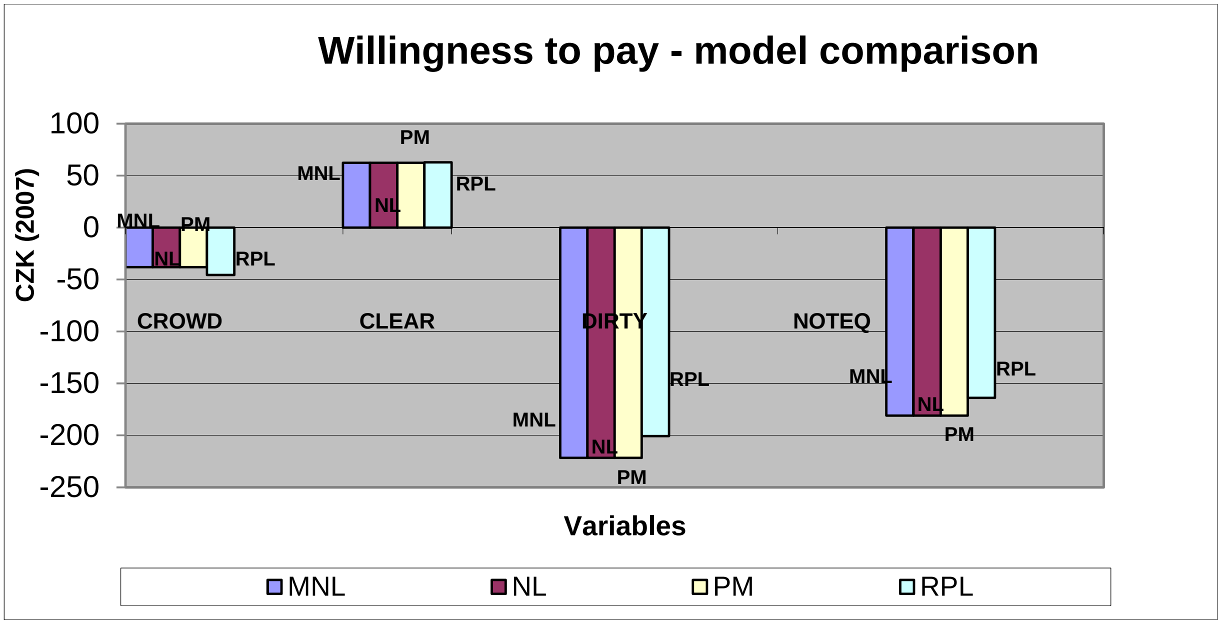
LEVEL 1 **Clean water**	No algae No cyanobacteria Swimming convenient
LEVEL 2 **Slightly polluted water**	Visible algae No cyanobacteria Swimming convenient
LEVEL 3 **Polluted water**	Strong algal occurrence Cyanobacterial occurrence Swimming inconvenient

Source: Own analysis

The questionnaire was administered on-site to visitors to the four paid beaches. Respondents were intercepted randomly and interviewed face-to-face by trained interviewers on each beach separately throughout the day. The survey resulted in a total of 333 completed questionnaires. The questionnaire was designed to be completed in 15 minutes in order to avoid respondent fatigue. The study population was the population of visitors to the paid beaches, which amounts approximately to 5/6 of all the visitors to Lake Mácha. The survey on the beaches was carried out between July and August 2007.

The analysis revealed the following preferences with the random parameter logit model giving the highest adjusted R^2 (0.304).

Figure 4: Marginal willingness to pay for a change in the attribute level; model comparison



Note: MNL = Multinomial logit model; NL = Nested logit model; PM = Probit model; RPL = Random parameter logit model. The explanatory variables used in the modelling exercise were: CROWD = Overcrowded beach, CLEAR = Water pollution level – clear, DIRTY = Water pollution level – dirty, NOTEQ = No equipment at the beach.

Source: Own analysis

The choice experiment data analysis showed that all the attributes used in the study are significant at the 1% level of significance and that dirty water is the factor that most significantly affects people's recreational utility. The results also showed the high value that vacationists place on all the attributes used in the choice experiment. People are willing to pay an additional CZK 63 for a day spent at the beach for clean water in the lake. The marginal willingness to pay for dirty water is significant and negative, amounting to more than CZK 200 for a day spent at the beach. The research gave very plausible results given the real entrance fee on the beaches per person and day amounting to CZK 40.

4.6 Analysis of visitation rate

The visitation rate for both scenarios/time periods is analysed separately in the following chapter. The visitation rate, defined as the number of person-days spent on the beaches, differs in both scenarios due to two main factors. Firstly, the visitation rate of the localities analysed as such differ in time due to many factors (e.g., changing tourist behaviour, people's changing purchasing power, changing water quality in the lake). Secondly, the spatial scales of the two scenarios differ due to the different area of water quality changes.

4.6.1 Key recipients of benefits

It is well known that the Orlík Reservoir is used mostly for recreation and water sports. As discussed above, we will analyse the influence of water quality changes on key recipients of benefits: tourists in some of the main accommodation facilities, owners of cottages and bungalows near the Orlík Reservoir, and local residents.

4.6.2 Definition of the Orlík recreational sub-region

The villages in the 5 km radius and towns in the 15 km radius from the shore of the Orlík Reservoir were included for the purpose of potential benefit estimation from reducing water eutrophication.

The area contains other natural water substitutes for the Orlík Reservoir. There are a lot of recreational facilities – boarding houses, hotels and, most importantly, campsites in this area. There are also plenty of cottages and bungalows on the shore and tens of houseboats constantly anchor there.

In the defined area, we can find 30 villages in the 5 km radius from the shore and 9 towns in the 15 km radius. In total, 11,500 inhabitants live in the villages and 51,000 in the towns.[11] There are 66 holiday home areas with approximately 2,860 holiday homes, most of them right by the shore.[12] Approximately 110 houseboats anchor in 7 main anchoring areas.

For the purpose of this analysis, it is necessary to further divide the area of the Orlík recreational sub-region used for recreation into several sub-areas depending on current and future water quality. Future water quality is considered after realisation of the cost-effectiveness scenario in the whole Orlík Reservoir catchment area. Figure 6 below gives maps of the present and future states of water quality. The scale of water quality in the maps goes from excellent to poor.

- Water in the "poor" category has large masses of algal bloom every year and it is not suitable for swimming at least from June to the end of September.
- Water in the "insufficient" category has the occurrence of algal bloom later, approximately from July to the end of September, but not every year. We estimate that it happens every other year.
- Water in the "sufficient" category is not very transparent (2 to 3 metres at most) and it has little algal bloom; most people in the Czech Republic would be very satisfied with swimming in it.
- Water in the "excellent" and "good" category is transparent on average to more than 4 metres and it is very attractive (even for diving).

For the benefit estimation purposes, we have to divide the Orlík recreational sub-region into 3 zones (Figure 5).

- **Zone 1** includes the upper part of the Orlík recreational sub-region area from Kořensko to Slabčice. The water quality in this zone will change from poor to insufficient. There will be algal bloom every other year here.
- **Zone 2** is formed by the middle part from Slabčice to the Žďákovský Bridge, where the water quality will change from poor to sufficient.
- **Zone 3** extends from the Žďákovský Bridge to the Orlík Dam and the water quality will change from insufficient or sufficient to good.

The village of Albrechtice nad Vltavou is included in zone 2 thanks to its good accessibility; the village of Čimelice is included in zone 3. Neither of the villages lies near the water, which is why it is necessary to use some form of transport. It can be assumed that people will likely be travelling slightly farther to have better water quality.

[11] The numbers of inhabitants were counted as the sum of numbers of inhabitants of each village. Albrechtice is marked in red, but is considered as a municipality in the 5 km radius.

[12] The numbers of holiday homes were counted as the sum of recreational buildings in the cadastral maps available at http://www.cuzk.cz.

Figure 5: Orlík Reservoir and division of its recreational sub-region into zones.

Source: Own using Google.cz map background

4.6.3 Visitation rates in the defined scenarios

4.6.3.1. Visitation rates for the benefit calculation in the 2007–2015 scenario

We used the data defined at the beginning of this chapter for the analysis of the visitation rate figures. The visitation rate is analysed only for the area where the water quality changes accrue and it is further divided for the purpose of the benefit calculation into zones according to the water quality changes.

The implementation of existing measures will result in a water quality improvement in (i) the Otava sub-catchment downstream of the confluence of the Lomnice and the Otava, and (ii) from the confluence of the Otava and the Vltava to the Orlík Dam. This implies a water quality improvement in (i) part of Zone 2 (from the discharge of the Lomnice into the Otava, and from the discharge of the Otava into the Vltava to the end of Zone 2), and (ii) all of Zone 3 (see Figure 5). In agreement with the Lake Mácha study (see below), the water quality in Zone 2 will improve from category 3 to category 2; the water in Zone 3 will improve from category 3 to category 2 for approximately one half of the visitors.

The visitation rate development in the area since 2007 is shown in Table 13; it is estimated for these areas based on the visitation rate trend for the entire Orlík area analysed. The visitation rate is expected to increase by 3% in 2014 as a consequence of the continuing trend of moderate increase in the recent years, observable since 2011, as well as improved water quality. A 5% increase is assumed for 2015 (it can be assumed that people will become aware of the improving water quality in the respective parts of the lake).

Table 13: Visitation rates in the Otava sub-catchment sub-region (between confluence of the Otava and Lomnice and Orlík Reservoir, part of Zone 2) and in Zone 3 between 2007–2015

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of overnight stays in accommodation facilities	159,213	112,386	84,290	88,972	91,782	93,655	93,655	96,465	101,288
Number of overnight stays in cottages and houseboats	64,960	64,960	64,960	64,960	64,960	64,960	64,960	66,909	70,254
Number of days spent by water by local residents	1,596	1,596	1,596	1,596	1,596	1,596	1,596	1,643	1,726
Total	**225,769**	**178,942**	**150,846**	**155,528**	**158,338**	**160,211**	**160,211**	**165,017**	**173,268**

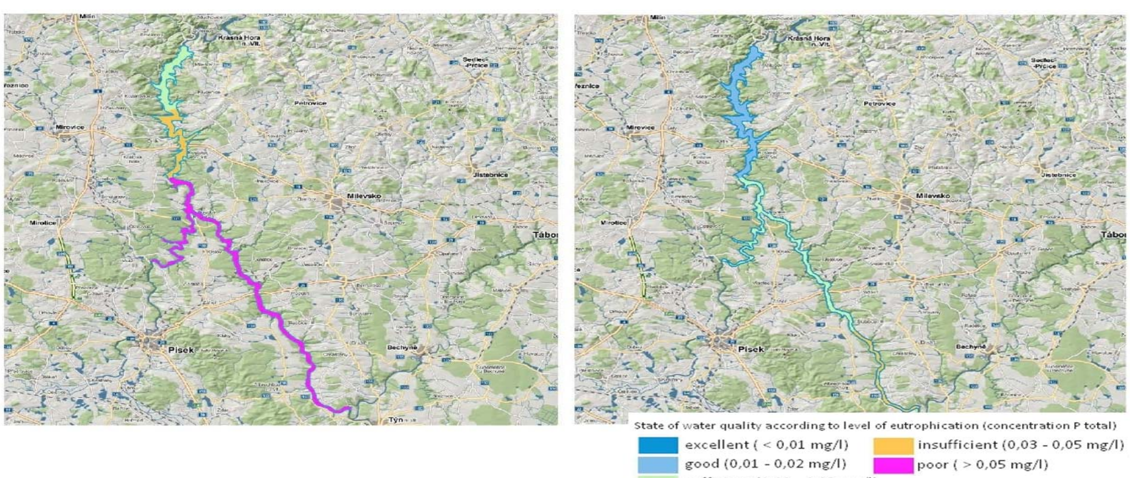
Source: Own analysis

It follows from the table that the average number of days spent at the Orlík Reservoir beaches was less than 200 thousand annually.

4.6.3.2. Visitation rates for the benefit calculation in the 2016–2035 scenario

In the 2016–2035 scenario, it is supposed that all the suggested water quality measures are applied. If this happens, the following water quality changes will occur (see Figure 6).

Figure 6: Current state of water quality in the Orlík Reservoir according to eutrophication indicators in 2006–2011 (left) and future state of water quality (right)



Source: Basin model of phosphorus inflow and outflow (Hejzlar et al., 2010)

Based on the data analysis, we found the following visitation rates (for the year 2012) in the territory/catchment area (see Table 14) influenced by the future water quality changes due to the water quality measure implementation.

Table 14: Total visitation rates in the Orlík recreational sub-region

	Zone 1	Zone2	Zone 3	Total
Number of overnight stays in accommodation facilities	12,645	158,563	62,833	234,041
Number of overnight stays in cottages and houseboats	12,560	60,160	45,440	118,160
Number of days spent by water by local residents	3,002	8,437	1,080	12,519
Total	**28,207**	**227,160**	**109,353**	**364,720**

Source: Original analysis

The presented figures for the **accommodation facilities** cover 22 municipalities. On the basis of this estimation, 234,041 nights were spent in the area (for the methodological approach adopted see part "4.5 Data sources and methods").

There are 2,842 **cottages and bungalows** in total; **112 houseboats** anchor in the area. Using the approach adopted for nights spent at the Orlík Reservoir, this amounts to 118,160 nights spent in total (for the methodological approach adopted see part "4.5 Data sources and methods").

Regarding local residents in the 9 towns and 30 villages with 62.5 thousand inhabitants in the catchment area, we assume 12.5 thousand days spent at the Orlík Reservoir (for the methodological approach adopted see again part "4.5 Data sources and methods")

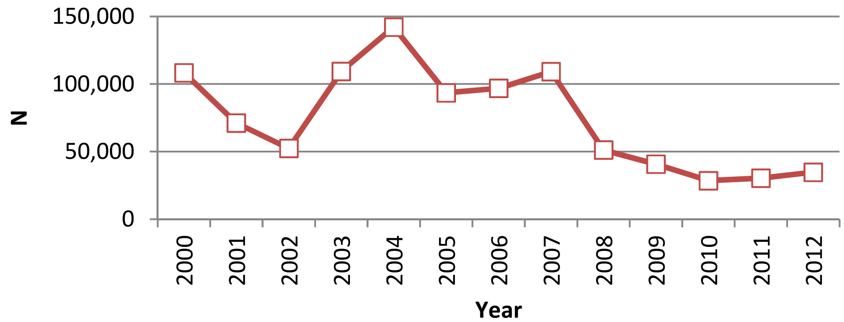
In total, there are 352.2 thousand nights spent at the Orlík Reservoir sub-region during the summer season. Most of these nights are in accommodation facilities right on the shore of the Orlík Reservoir, approximately one third of these nights is attributed to the people who use the cottages and bungalows. Together with local residents, this is approximately 364.7 thousand nights spent.

4.6.4 Future trends in visitation rates

In spite of the fact that the South Bohemian region (where the bigger part of the Orlík Reservoir lies) is considered to be one of the most attractive regions for tourists in the Czech Republic, the visitation rate is decreasing. The same trend is shown by the Orlík Reservoir itself. The drop of the visitation rate most negatively affects campsites. For example, the village of Milešov (320 permanent inhabitants) has several campsites on its cadastral territory and its number of nights spent dropped to one third of its original count from 2000 to 2012.

The exceptions are the years 2006 and 2007, when the highest peak occurred even in comparison with 2000. The biggest decline was in 2002 and 2008−2009. The year 2002 is connected with big floods. The onset of economic recession had its influence on the numbers in the years 2008 and 2009. According to Czech Statistical Office data, there was a mild increase in the visitation rates in the South Bohemian region in 2012. The trend of the numbers of overnight stays is already well reflected by the above mentioned village of Milešov (Figure 7).

Figure 7: Number of overnight stays in Milešov in 2000–2012



Source: Czech Statistical Office

Since 2000, the vacation time in the South Bohemian region has shortened from the average of 4.4 nights to 2.9 nights.[13]

The reasons for the decrease differ greatly. Several tourism experts, regional offices and camp providers were asked as part of the present study. The most common reasons for the decrease in the visitation rates were (among others) those named below:

- poor water quality
- poor infrastructure in the region (no highways, bad condition of roads, insufficient public transport for tourists)[14]
- insufficient and disunited promotion of the South Bohemian region
- lack of other activities in the area in the case of bad weather, water parks, etc.
- unsuccessful privatisation of some recreational facilities and other services for tourists, problems connected with ownership of these facilities
- no development management (there were no projects for OP EU and no money were gained for development of, e.g., infrastructures)
- no knowledge about investments (local residents not involved in running business, everything managed by people from outside; local residents not educated in tourism and investment and they have insufficient financial support)

Within the analysis of visitation rates, we contacted campsite providers in our defined area in the course of July 2013. Two providers from the largest campsites gave us the following information on their visitors:[15]

- The reason for decreasing visitation might be in the worsening economic situation of Czech households. People shorten their holidays or cancel them completely. This year is especially surprising because both the water and the weather are fine and people did not come.
- People sometimes call to find out what the water quality is (but not very often).

[13] Czech Statistical Office data

[14] Tourism Development Strategy for the South Bohemian region for the years 2009–2013 (Piskacek & Benes Consulting s.r.o. (2009): Strategie rozvoje cestovního ruchu v Jihočeském kraji na roky 2009–2013)

[15] Velký Vír campsite and Radava campsite

- One of the camp providers confirmed that more people would come if the water quality increased significantly, but he did not show any enthusiasm about a significant increase in water transparency.
- The camp providers did not confirm that the visitation rate would significantly increase if the water quality increased. However, they confirmed that water quality is probably one of the factors that plays a role when people are deciding whether to visit Orlík or not.
- What matters is the incorrect information in media saying that the water quality is worse than it is in reality (especially warnings that swimming is prohibited).
- The reduction in the visitation rate is probably reflecting the economic situation of households and better affordability of foreign package tours (thanks to their decreasing prices). It is a more complex matter.
- People shorten their holidays. Some people make a booking several months ahead; these people pay a booking fee and they are therefore forced to come. However, they run the risk that the water will be worse at the time of their holiday. This risk is eliminated when going to the sea.

5. Economic efficiency assessment

The economic efficiency is assessed separately in two analysed scenarios, i.e., in the 2007–2015 and 2016–2035 time horizons. Benefits differ in both scenarios firstly because of different visitation rates and secondly because of the different water quality changes in the different areas of the region analysed. The 9-year time horizon of the first scenario corresponds to the DA guideline recommendation. The 20-year time horizon of the second scenario corresponds to the length of 20 years considered in the CEA. The costs in both the scenarios differ as well. The 2007–2015 scenario costs are easy to describe as they express the real or projected costs of the application of the water quality measures in the time horizon. The lifespan of the measures is calculated to be the same as in the CEA scenario (namely 20 years). The costs of the 2016–2035 scenario consist of the costs already realised in the 2007–2015 scenario and, starting from 2016, also the costs of the application of the water quality measures of the cost-effectiveness scenario. The 2007–2015 costs disappear from the 2016–2035 scenario in 2027 as the 20-year lifespan is completed (2007–2026).

5.1 Benefit assessment for the 2007–2015 time horizon

As mentioned above, the benefit transfer made use of the most appropriate study carried out in the Czech Republic in the 2007, a study on Lake Mácha called “Analysis of the Economic Impacts of Water Eutrophication: Lake Mácha Case”. This study was described in detail in Chapter 4.5.1.

A model was built for the purpose of the benefit transfer. The inflation rate and the wage increase since 2007 were taken into account among the benefits. All the benefits were discounted. To discount the benefits and costs, a social discount rate of 5.5% was used, which is recommended by the European Commission for the Cohesion Countries (EC, 2008). The inflation rate is supposed to be 2% after 2013 and the wage increase is supposed to be 1% after 2013. The benefits were expressed in CZK 2007 real values and the costs were taken as the real values.

Taking into account all these aspects, the following WTP for the water quality improvement was obtained (Table 15).

As evident from Table 16, the additional WTP (utility increase) for a day at the lake without cyanobacteria is CZK 157; the WTP for an improvement in the in-depth visibility is CZK 49 for a day spent on the beach.

Table 15: Marginal willingness to pay for water quality improvement (CZK per visit)

Improvement	Original study Lake Mácha (CZK 2007)	Original study Lake Mácha (CZK 2013)	BT study (Orlík Reservoir) 2/3 of the original value (CZK 2013)
level 3 to level 2	200	236	157
level 2 to level 1	63	74	49
level 3 to level 1	263	310	206

Source: Own analysis

In the time horizon in question, based on the current water quality and the expected water quality, it is possible to distinguish three basic categories of improvements analogous with the Lake Mácha study, which are shown in Table 16.

Table 16: Benefits for defined water quality changes

Original water quality	Water quality after measures (improvement "from level"-"to level")		
	insufficient	**sufficient**	**good**
poor	**3 - 2 (benefits only every second year)**	**3 - 1**	–
sufficient	–	–	**1 – 1**
insufficient	–	–	**3 - 1 (every year) 3 - 2 (every second year)**

Source: Own analysis

As discussed in Chapter 4.6.3.1 („Visitation rates for the benefit calculation in the 2007–2015 scenario"), the water quality has changed in part of the zone 2 and the whole of zone 3. The water quality change can be defined as a change from poor water quality to insufficient water quality on the Lake Mácha study scale, which is in accordance with the change from level 3 to level 2 in Table 16.

Having these figures, we set the model for the cost benefit analysis. The model brings the following results (see Table 17):

Table 17: Cost-benefit analysis of water quality measures at the Orlík Reservoir in the 2007–2015 scenario

PARAMETER	Percentage of benefits included	Discount rate	Total benefits (CZK mil.)	Total costs (CZK mil.)	Benefits - costs
VALUE	**65**	**5.5**	**256**	**4,026**	**-3,770**

Source: Own analysis

In the model, we supposed that only 65% of all the benefits were covered by the analysis of the recreation benefits. The model revealed that the discounted benefits in the 2007–2015 scenario amount to **CZK 256 mil.** (EUR 9.5 mil.) while the discounted costs for the same period amount to **CZK 4,026 mil.** (EUR 149 mil.) with the net social benefits amounting to **CZK -3,770 mil.** (EUR -140 mil.).

The results mean that there is a net loss for society. The policy consequences of the results are discussed in the final chapters.

5.2 Benefit assessment for the 2016–2035 time horizon

As mentioned for the benefit transfer, we used the most appropriate study done at Lake Mácha in the Czech Republic in 2007, called “Analysis of the Economic Impacts of Water Eutrophication: Lake Mácha Case”. This study was described in detail in Chapter 4.5.2.

A model was built for the purpose of the benefit transfer. The inflation rate and wage increase since 2007 were taken into account in the benefits. All the benefits were discounted. To discount the benefits and costs, a social discount rate of 5.5% was used, which the European Commission recommends for Cohesion Countries (EC, 2008). The inflation rate is supposed to be 2% after 2013, and the wage increase is supposed to be at 1% after 2013. The benefits were expressed in CZK 2007 real values and the costs were taken as the real values. The costs come from the CEA but were recalculated from the original 4% discount rate. The values of the costs and benefits are comparable throughout the time horizon.

Taking into account all these aspects, the following WTP for the water quality improvement was obtained (Table 18).

Table 18: Marginal willingness to pay for water quality improvement (CZK per visit)

Improvement	Original study Lake Mácha (CZK 2007)	Original study Lake Mácha (CZK 2013)	BT study (Orlík Reservoir) 2/3 of the original value (CZK 2013)
level 3 to level 2	200	236	157
level 2 to level 1	63	74	49
level 3 to level 1	263	310	206

Source: Own analysis

As evident from Table 18, the additional WTP (utility increase) for a day at the lake without cyanobacteria is CZK 157; the WTP for an improvement in the in-depth visibility is CZK 49 for a day spent on the beach.

In the time horizon in question, based on the current water quality condition and the expected water quality, it is possible to distinguish three basic categories of improvements analogous with the Lake Mácha study, which is shown in Table 16. Based on these figures, i.e., the WTP adopted from the original study, the expected water quality improvements, and the person-days spent at the lake calculated above, we can fit the particular zones to the WTP in the BT study according to Table 19. Having these figures, we set the model for the cost benefit analysis with the parameters being discussed in Table 20.

Subsequently, we specified several cost benefit analysis models. The **realistic scenario** presents the most probable benefit size from our point of view in all the explored parameters, that is, in terms of the expected visitation rate (1.8 multiple of the contemporary value), visitors’ real WTP for the water quality improvement (the same as for Lake Mácha) and also the percentage of the benefits that we included in the scenario (65% of all the benefits covered).

Table 19: Water quality benefits per person-day in particular zones of the Orlík Reservoir recreational sub-region

<table>
<tr><th></th><th>Number of person-days spent at Orlík Reservoir</th><th>Original water quality</th><th>Water quality after measures</th><th>Level of improvement</th><th>Time of repetitiveness of the benefits</th><th>WTP per person-day</th></tr>
<tr><td>Zone 1</td><td>28,207</td><td>poor</td><td>insufficient</td><td>3 - 2</td><td>Every second year</td><td>157</td></tr>
<tr><td>Zone 2</td><td>227,160</td><td>poor</td><td>sufficient</td><td>3 - 1</td><td>Every year</td><td>157+49</td></tr>
<tr><td rowspan="2">Zone 3</td><td rowspan="2">109,353</td><td>sufficient (1/2 of the visitors)</td><td>Good</td><td>1 - 1</td><td>Every year</td><td>0</td></tr>
<tr><td>insufficient (1/2 of the visitors)</td><td>Good</td><td>3 - 1
3 - 2</td><td>3 - 1 (every year)
3 - 2 (every second year)</td><td>157+49
157</td></tr>
</table>

Source: Own analysis

Table 20: Specification of model parameters

	Interval	Description	Purpose
Visitation rate	1.4–4.7	Change in the visitation rate during the period	Deals with the uncertainty regarding the number of people coming to the lake
WTP (multiple of value)	0.7–3.8	Multiple of the basic scenario value	Deals with the uncertainty of the benefit estimation
Percentage of benefits included	45–90	Supposed percentage of total benefits from improved water quality	Deals with the uncertainty of the size of non-covered benefits
Discount rate	4–8	Discount rate of benefits and cost in the whole period	Deals with the uncertainty of the real social discount rate

Source: Own analysis

The **pessimistic scenario** presents the most pessimistic benefit size estimates from our point of view again in all the explored parameters, that is, in terms of the expected visitation rate (only 1.4 of the contemporary visitation rate), visitors' real WTP for the water quality improvement (only 0.7 multiple of the Lake Mácha WTP) and also the percentage of the benefits that we included in the scenario (90% of all the benefits were covered by the analysis of recreationists).

After these scenarios were done, we found out that the NPV parameter is highly negative in all of them, which suggests that the water quality measures should not be implemented from the economic efficiency point of view. After this finding, we decided to create an additional scenario that would show what parameter values the model would have to satisfy so that the NPV is not negative.

We called this scenario the "**balanced scenario**". The model has the following parameters: expected visitation rate (4.7 of the contemporary visitation rate), visitors' real WTP for the water quality improvement (only 3.8 multiple of the Lake Mácha WTP) and also the percentage of the benefits that we included in the scenario (45% of all the benefits were covered by the analysis of recreationists).

The costs and benefits of these models are adjusted by applying the appropriate discount rate. The costs used again come from the CEA scenario and are appropriately modified from the original 4% discount rate. The models are described in more detail below with the following results (Table 21). The net present value was used as an indicator.

Table 21: Cost-benefit analysis of the water quality measures in the Orlík Reservoir basin 2016–2035

SCENARIO	Visitation rate	WTP (multiple of value)	Percentage of benefits included	Discount rate	Total benefits (CZK mil.)	Total costs (CZK mil.)	Benefits - costs
Optimistic	2.7	1.5	50	7	3,974	13,659	-9,685
Realistic	**1.8**	**1.0**	**65**	**5.5**	**2,002**	**15,247**	**-13,245**
Pessimistic	1.4	0.7	90	4	1,071	17,158	-16,087
Balanced	**4.7**	**3.8**	45	8	12,750	12,750	0

Source: Own analysis

(1) Optimistic scenario

Visitation: We count with a moderate annual increase in the visitation by 5−10% in first three years, then a 15% increase with an apex of 20% increase in 2019, followed by only a 5 to 1% annual increase in the rest of the period. The assumption is that people would notice the high water quality and start to use the lake for their recreation. This would cause development of tourist infrastructure, which would attract even more people. The visitation level would stabilize after approx. 7 to 10 years.

WTP: We suppose that the WTP values used were underestimated; therefore a 1.5 multiple of the basic scenario value was used.

Percentage of benefits included: We suppose that recreational utilities at the Orlík Reservoir cover only 50% of the overall utility increase that would come with the water quality increase.

In this scenario, the discounted benefits in 2016–2035 are **CZK 3,974 mil.** (EUR 147 mil.), while the total discounted costs for the same period are **CZK 13,659 mil.** (EUR 506 mil.), with the net social benefits amounting to **CZK -9,685 mil.** (EUR -359 mil.). In the optimistic scenario, the overall costs exceed the benefits.

(2) Realistic scenario

Visitation: We count with a moderate annual increase in the visitation by 2−7% in first three years, then a 10% increase with an apex of 15% increase in 2019, followed by only with a 3 to 1% annual increase in the rest of the period. The assumption is similar as in the optimistic scenario, only the visitation increase estimation is more careful. People in this scenario would notice the high water quality and start to use the lake for their recreation. This would cause development of tourist infrastructure, which would attract even more people. The visitation level would stabilize after approx. 7−10 years.

WTP: The WTP values used are the same as in the Lake Mácha case.

Percentage of benefits included: We suppose that it is realistic to assume that the recreational utility connected with significantly higher water quality at Orlík covers 65% of the overall utility increase.

In this scenario, the discounted benefits in 2016–2035 are **CZK 2,002 mil.** (EUR 74 mil.), while the discounted costs for the same period are **CZK 15,247 mil.** (EUR 565 mil.), with the net social benefits amounting to **CZK -13,245 mil.** (EUR -491 mil.). There is a net loss for society amounting to CZK 13,245 mil. (EUR 491 mil.) in the realistic scenario.

(3) Pessimistic scenario

Visitation: We count only with a very low increase in the visitation rate in the whole period. The increase amounts to only 1.4 of the original visitation in this scenario, which means that the Orlík Reservoir would not become significantly more popular in a situation of clean water.

WTP: We count that the WTP in the realistic scenario was overestimated, therefore only 0,7 of this value was used.

Percentage of benefits included: We suppose that the recreational utility connected with the significantly higher water quality covers 90% of the overall utility increase at the Orlík Reservoir.

In this scenario, the discounted benefits in 2016–2035 are **CZK 1,071 mil.** (EUR 40 mil.), while the discounted costs for the same period are **CZK 17,158 mil.** (EUR 635 mil.), with the net social benefits amounting to **CZK -16,087 mil.** (EUR -596 mil.).

(4) Balanced scenario

Since the net social benefits in all the previous scenarios were negative, we decided to set an additional scenario that is balanced so that the net social benefits are zero. In order to get positive results, we set the following model specifications:

Visitation: The visitation rate would have to increase 4.7 times.

WTP: The WTP used would have to be underestimated 3.8 times.

Percentage of benefits included: Recreation would have to cover only 45% of the overall utility increase at the Orlík Reservoir.

Under these assumptions, we get zero social benefits.

The policy consequences of the results are discussed in the following chapters.

6. Distributional effects

Distributional effects are described qualitatively based on comparison of pollution sources, cost bearers and beneficiaries (see again the WP6 Methodological approach to Disproportionality Analysis). The comparison is done by sectors, not individual actors – i.e., municipalities, fisheries and farmers. An important source of information was the stakeholder meeting held in Písek in the winter of 2013 (for more detailed information, see the separate project report "Second stakeholder engagement process in the Vltava catchment, Czech Republic – disproportionality analysis and flagging the wider benefits" developed by Slavíková et al. in 2013).

As mentioned in Chapter 1, the average phosphorus discharges in 2007-2009 are as follows (total annual inputs of 288.2 tons):

- 55% from municipalities,
- 22% from fisheries,
- 12% from agriculture.

In 2007–2015, the discharges were reduced by approximately 22 tonnes with the following investments implemented at the total annual costs of CZK 465 mil.

To reach the environmental target, the discharges have to be reduced by an additional 114 tonnes. There were about 3,097 possible applications of measures in the whole Orlík catchment, of which 1,610 have been evaluated as the most cost-effective to reach the goal of the total phosphorus reduction. Within the CEA, the measure applications were suggested with the following structure of cost bearers with the total annual cost of CZK 602 mil. (EUR 22 mil./year), where:

- 51% by fisheries,
- 44% would be covered by municipalities,
- 5% by agriculture.

Regarding the sector involvement, 96% of the identified applications of measures on ponds and 66% of the identified applications of measures in agriculture entered the most cost-effective scenario. This means that almost the entire **fishery sector** in the area would be burdened with costs represented by a reduction in carp production from 650 kg/ha/year to 150 kg/ha/year to reach a negative phosphorus balance. Regarding **farmers**, most of the applications of measures were proposed on land that is adjacent to water bodies or on steep fields – so only those farming there would be burdened with extra costs. Finally, applications of measures regarding the municipal sewage treatment plant intensifications and sewerage renewal or development were included in those **municipalities** where it was found economically efficient (in comparison with alternative measures). 71% of the identified potential applications of measures at point sources are included in the cost-effectiveness scenario (i.e., 1,278 applications of measures in municipalities). See Table 11 for a cost bearer overview in both the scenarios 2007–2015 and 2016–2035.

In this context the proposed cost distribution, the burdens differ significantly in both the time horizons. In the case of applications of water quality improvement measures already implemented, the highest share of the costs is paid by the municipalities, followed by the fisheries and agriculture, while in the CEA scenario the highest share of the costs will be borne by the fisheries due to their relatively low phosphorus abatement costs compared to the others.

During the Písek workshop, the introduction of the cost-effectiveness scenario raised strong emotions and it was opposed as economically unsound. Especially pond owners and managers refused the proposition that they cause almost 1/4 of the phosphorus releases and they asked for more detailed monitoring.

Then, the workshop participants were asked who should be the main cost bearer of the problem solution. Responses were gathered via individual questionnaires and further discussed in the plenary discussion. There was a consensus that municipalities should be the main investors. Interestingly, municipalities labelled themselves as such, too. Pond owners and farmers stressed the important role of the state budget, which should strongly support any solution. Institutional (from state organisations) and municipal representatives also thought that important cost bearers should be tourism entrepreneurs, who would gain from the water quality improvement. With the exception of the municipal representatives, all the other stakeholder groups (farmers, pond owners and institutions) labelled themselves as the least likely potential payers. In general, a strong reliance on government subsidies is still the common practice in the CR when discussing public interests.

One representative of tourism entrepreneurs was present at the workshop, but he did not express any strong opinion regarding the demand for water quality improvement. The discussion was therefore dominated by the opposition of cost bearers.

At the end, attention must be paid to the cost-benefit relations of the particular sectors, especially:

a) Are the costs outweighing the benefits or vice versa?
b) What is the capacity to pay?
c) Is the goal affordable in terms of the current WFD implementation (in terms of application of measures contained in the river basin management plan?

It is clear from the data presented that the fishery sector is supposed to be the greatest net payer while getting only minimal benefits in return. Applications of measures on ponds related to fish reduction (and change of management practices) are quite cheap, so it is efficient to pursue them. However, fishermen are not direct receivers of recreational benefits (above their individual recreational activities). A similar situation is with the farmers, although they will not be so heavily burdened and they are also more open for the discussion of feasible options. Municipal representatives are willing to seek for particular measure designs – they are both cost bearers and benefit receivers of the future change. The tourism entrepreneurs were under-represented at our stakeholder workshop and in general they seem to be poorly organised (in comparison to, e.g., fishermen), so we do not know their views or options. Currently, they seem to be the future net benefit receivers. Generally, there is a possibility to discuss some kind of compensations among the tourism sector and the main cost payers, but we have not proceeded further in these discussions.

The greatest problem is the capacity to pay for all the cost bearers, who stress it as very low. The pond owners and managers and the farmers stated that they are willing to adopt changes providing they are subsidised. This position is stronger in the case of farmers, who have already been aware of countryside compensation schemes. Pond owners and managers are very reluctant to any kind of changes because they do not see themselves as a part of the problem. Municipalities are willing to adopt measures, but they have a very limited capacity to act. In the Czech Republic, there are many very small self-governed municipalities up to 500 inhabitants (this is mostly the case in the Orlík surroundings). They are not able to generate enough money for large investments; so again, they depend on subsidies from the state budget.

With respect to the current WFD implementation, there are serious doubts regarding the affordability of the P reduction goal. The goal for the purpose of the CEA analysis is set above the current political target (and reflects the true necessity of reaching a GES). Based on information from the Vltava river basin management plan (valid in 2009–2015), there are not enough applications of measures to reach a GES for the Orlík reservoir by 2015. The main reason is a total absence of measures for regulation of the fishery sector and the low number of measure applications regarding wastewater treatment (due to financial reasons). If the eutrophication is significantly reduced, a larger number of measure applications, but also a larger variety of measures should appear in the river basin management plan for the years 2016–2021.

The beneficiaries are the same for both the scenarios and, as is described in the previous subchapter, beneficiaries are holders of the water-related benefits coming from the water quality improvement – the tourism entrepreneurs and the public represent the main groups in focus. They can be described as follows:

- Providers of camping sites, hotels, hostels and other types of commercial accommodation;
- Providers of other leisure-time services, such as restaurants, yacht docks, etc.;
- Municipalities (via extra revenues to municipal budgets, e.g., through the leisure-time fee per night paid in the price of accommodation, through entrepreneurs' income tax);
- Owners of private holiday homes, individual anglers, local people spending leisure-time at Orlík (informal recreation).

Regarding the distributional effects, it has to be mentioned that the beneficiaries will not directly contribute to the application of the water quality measures. On the other hand, it has to mentioned that as they are Czech residents, they pay taxes and the application of the water quality measures at the point sources will be financed mostly from public budgets: they are covered in fact form tax revenues.

However, the situation is not the same for the fisheries and agriculture as they prevailingly will not benefit from the water quality improvement – the contrary is true in the case of the fisheries. By nature, the water quality measures mean direct net profit losses as they mean restriction of the intensive fish farming and reduction of the fish yields in the ponds. The fisheries are therefore net losers and in order to be willing to cooperate on the CEA scenario realisation, they will have to be compensated or the pond managers have to be legally required.

PART III: Conclusions and Policy Implications

7. Conclusions on CEA and disproportionality analysis findings

This report presents outcomes of the cost-benefit and distributional analyses of the application of water quality measures at the Orlík Reservoir for compliance with the WFD target of good ecological potential. The analysis is done separately for two different time horizons: 2007–2015 and 2016–2035. The costs of applications of measures to improve water quality already implemented and corresponding benefits are assessed in the first time horizon of the analysis. In the second time horizon, the cost effectiveness analysis to achieve the objectives of the WFD is done and also corresponding benefits are analysed. The issue of disproportionality is also covered in the second time horizon.

The Habitats Directive sets targets of favourable conditions for species and habitats (FC) in Special Protection Areas (SPA), which depending on the context can be more stringent than WFD requirements for good ecological status. There are two SPAs (Třeboňsko and Řežabinec bird protection areas) as well as two other European potential Sites of Conservation Interest (pSCI) (Českobudějovické rybníky and Dehtář bird protection areas) in the upper River Vltava basin (Kontolaimou et al., 2010; Deliverable 6.1) that are related to the aquatic environment, in addition to several hundred other terrestrial SPA and pSCI sites. However, consultations with expert ecologists indicated that the FC of these SPAs and pSCIs will not be significantly affected by the phosphorus targets considered here, and therefore cost-effectiveness and disproportionality considerations remain as specified in accordance with the WFD principles.

Regarding benefits, both the CEA and disproportionality analyses focused only on evaluating the impacts relating to the Orlík recreational sub-region. As previously mentioned, it should be noted that significant benefits will take place outside the outlined area, because water quality will also improve upstream and downstream of the Orlík Reservoir. The importance of these benefits is very difficult to quantify, because of the scale of the region and because of the reciprocal interactions among uses of different water bodies and different parts of the region. In our research, we identified the costs and benefits connected with the improvement of poor water quality. Based on experience with a similar environmental stressor from previous research, we decided to focus on the recreational benefits, which we believe is the dominant factor when analysing loss of benefits due to eutrophic water. It should, however, be noted that this is not the only benefit (see also Chapter 4.2).

A price increase of holiday homes is expected in the case of a large increase in the visitation rate. The increase in visitation rates associated with clean water will also have a positive impact on employment. Quantification in this area can hardly be done as employment and price increases depend on many other aspects. For more accurate results of the benefit assessment, it would be necessary to carry out a primary valuation at the local level. It might be possible to determine the exact willingness to pay through data collection and possibly a choice experiment. Unfortunately, there has been no budget in the WP6 for these purposes.

The sources of pollution at the Orlík Reservoir were analysed in the project. The analysis revealed the following pollution sources (phosphorus discharges):

- 55% by municipalities,
- 22% by fisheries,

- 12% by agriculture.

The costs of the application of water quality measures were analysed in two scenarios: one real scenario going back from 2007–2015, and another theoretical cost-effectiveness scenario following the 2016–2035 time horizon (see Table 11 for details).

The probable water quality changes were estimated based on the measures implemented and suggested in both scenarios, and the following benefits were calculated with a focus on the recreational benefits (given the benefit transfer study used). Having these figures, we set the models for the cost benefit analysis with the results shown in Table 17. In the model, we supposed that only 65% of all the benefits were covered by the analysis of the recreational benefits. The model revealed that the discounted benefits in the 2007–2015 scenario amount to **CZK 256 mil.** (EUR 9.5 mil.), while the discounted costs for the same period amount to CZK 4,026 mil. (EUR 149 mil.), with the net social benefits amounting to **CZK -3,770 mil.** (EUR -140 mil.). The results mean that there is a **net loss for society**.

The benefits in particular scenarios for 2016–2035 are given in Table 21. **In the realistic scenario**, the discounted benefits are **CZK 2,002 mil.** (EUR 74 mil.), while the discounted costs for the same period are **CZK 15,247 mil.** (EUR 565 mil.), with the net social benefits amounting to **CZK -13,245 mil.** (EUR -491 mil.). There is a net loss for society amounting to **CZK 13,245 mil.** (EUR 491 mil.) in the realistic scenario.

As is clear from the above results, there is a net **social loss in both the time horizons**. Therefore, the application of the water quality measures cannot be recommended based solely on the cost-efficiency criteria. A lower net social loss was found in the 2016–2035 time horizon due to the higher benefits and lower costs (given by the CEA approach). However, the sensitivity (scenario) analysis done for this time horizon showed that in order to reach positive net social benefits, very improbable values of the scenario variables (visitation rate; WTP, percentage of benefits included, discount rate) have to be set (see the “balanced scenario” for details).

Regarding the relations among the cost bearers and the beneficiaries, a serious asymmetry was found in the case of the fishery sector – the majority of the pond owners and managers are supposed to bear extra costs in the cost-effectiveness scenario but without receiving benefits coming from the improvement of water quality in the Orlík Reservoir. We need to emphasize that the fishery sector here is not represented by anglers, but by intensive producers of carps (there are large ponds in the whole Vltava River basin). Thus, there are hardly any benefits for them except compensations for the reduced carp production. On the other hand, tourism entrepreneurs would receive benefits without bearing the costs. The cost-benefit situation is balanced in the case of municipal representatives and potentially the local population as well. The municipalities are supposed to pay for the applications of measures, but they will also enjoy the benefits coming from the tourism development. Finally, farmers also seem to be net cost bearers, but the asymmetry is not as significant as in the case of the pond owners and managers. Also, the extent of their contribution is not as high. They might also benefit from agro-tourism in future. In this regard, the analysis pointed out one very crucial methodological issue. The cost-effective scenario may suggest that the highest expenditures for water quality measure implementation should be paid by those who do not have any benefits from the water quality improvement (for example the fisheries in the catchment – they only have costs). What mechanism should be applied then? Should it be a cost-effective way of water quality measure implementation (i.e., least costs for society as a whole) or some other ranking of water quality measure implementation (for example to follow up on the effort to balance the costs and benefits for particular stakeholders)? In our opinion, this is a crucial issue in searching for socially acceptable policy.

The analysis also showed the great importance of economic analysis even in respect of this serious problem. There were a lot of combinations of applications of particular measures to improve the water quality, but there is only a limited number of cost-effective combinations. This means that the same target can be reached at a triple cost if proper analysis is not done and the suggestions are not implemented in practice.

8. Policy implications and recommendations

Policy implications and recommendations must be considered in light of the methodological challenges of the disproportionality analysis undertaken and the stakeholders' views of the current situation.

First, it needs to be emphasised that the Orlík Reservoir analysis represents the very first comprehensive cost-benefit calculation in water management on a Czech national scale. Therefore, it faces a series of methodological issues, namely regarding data accessibility and comparability, the consideration of wider benefits, etc. Nevertheless, it clearly shows how to gain from the application of socio-economic tools at the local level. Within the next steps, the benefit side of the analysis could be supported with original data collection and evaluation. Also, the tourism databases could be significantly improved to provide more detailed information about (potential) beneficiaries. When considering the hydrological issues, multiplication effects of the goal of the reservoir water improvement should be considered on the river basin scale to better capture additional benefits.

Despite of numerous uncertainties, we should not completely omit the information that the Orlík Reservoir water quality improvement is very costly (namely due to numerous infrastructural investments in small municipalities) and that all the potential cost bearers refuse or declare their inability to bear the costs (we will come back to this in the paragraphs below). There is no doubt that it is necessary to decrease the P inflow into the reservoir, but (in our opinion) the results of the disproportionality analysis open room for a discussion of possible trade-offs (e.g., intensive carp production versus tourism development in the region). It was revealed that municipalities by themselves cannot solve the eutrophication problem: other sectors must be involved as well. Ultimately, the analysis results could help justify the exemption from the GES as enabled in the WFD (Art. 4).

There is also no doubt that planning authorities should do a better job regarding the use of expert knowledge in river basin plan creation than they did in the first planning period. In this context, results acquired within the REFRESH project could help. Specifically, the improvement should contain better specification of pollution sources and an enlarged list of measures (and their applications). For example, in the previous planning period the carp production was completely omitted, even though it represents an important activity regarding the P releases and possible reductions.

A positive impact on future decision-making was brought by the stakeholder engagement process, which had not been organised properly in the first planning period (see Slavíková and Jílková, 2009, for details). At the beginning, stakeholders helped define possible measures. Positions of different interest groups were revealed within the second consultation, and they can be counted with in development of policy recommendations. For instance, it must be further investigated to what extent the fishery sector releases P into the Orlík Reservoir – the CEA input data were questioned and the pond owners and managers argued with their own monitoring and the role of historic burdens in ponds. This scientific conflict needs to be resolved before any discussion with this stakeholder group will proceed further.

Stakeholders were also given room to express their local views and perceptions on the issue of disproportionality. There was consent that the municipalities should be the main investors. Interestingly, municipalities labelled themselves in agreement with this point. Pond owners and farmers stressed the important role of the state budget, which should strongly support any solution. Institutional and municipal representatives also thought that tourism entrepreneurs should be important cost bearers. With the exception of municipal representatives, all the other stakeholder groups (farmers, pond owners and institutions) labelled themselves as the least likely potential payers. In general, a strong reliance on government subsidies is still the common practice in the CR when discussing public interests.

In the future, there is a clear room for development of locally organised payments for ecosystem services (from the tourism sector to fisheries or agriculture). However, tourism entrepreneurs and the regional government would need to play a more active part in this context. Also, the limits of the state budget (or other public funds) must be articulated clearly and realistically to stakeholders to make them think about locally or regionally feasible solutions.

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