DELIVERABLE 3.5

Cost-effectiveness of selected mitigation measures for the case areas

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1 INTRODUCTION

Eutrophication is related to high anthropogenic nutrient inputs, such as nitrogen (N) and phosphorus (P), and represents a key concern within most catchments and is identified as one of the major ecological problems for both surface waters and the Baltic Sea itself (Artioli et al., 2008; Kiedrzyńska et al., 2014). In the BONUS MIRACLE project, the hypothesis is that innovative approaches to mitigate this nutrient input cannot focus on the nutrient issue alone but should involve new constellations of stakeholders with issues that are interconnected with eutrophication. It is therefore important to analyse both the costs-effectiveness, regarding N and P mitigation, and the benefits associated with different measures. This deliverable focuses on the cost-effectiveness of mitigating N and P from selected existing and potential new measures as suggested by stakeholders in the social learning process of the project. The concept of analysing the cost-effectiveness of measures mitigating N and P was briefly introduced in deliverable 3.4, and will be further elaborated in the following report, which serves as deliverable 3.5.

After giving an overview of the components of the Cost-Effectiveness Analysis (CEA) in chapter 3, the updated results of the measures, which were suggested by local stakeholders at workshops in Germany, Latvia, Poland and Sweden, are outlined in chapter 4. The CEA is based on the previously assessed cost structures and the currently available HYPE-modelling results from work package 2. At the time of writing the current report, work package 2 has also completed modelling the impact of future land-use and climate change on water flow and nutrient transport in some of the four case areas. Furthermore, the results presented in this report have provided input to the interaction with stakeholders in the workshops organized in WP5, which is elaborated in chapter 5. Overall, the cost-effectiveness results reveal the importance of considering multiple beneficial effects of the measures. These additional benefits were addressed in the reports D3.3 and D3.4, and will be further elaborated on in the upcoming deliverables 3.6 and 3.7.

2 The MIRACLE Project

2.1 Project Charter

Mediating integrated actions for sustainable ecosystems services in a changing climate

More than 85 million people live in the Baltic Sea catchment area, and around 60-70 % of the land is farmland. Thus, the agriculture sector and wastewater treatment sector are key actors that have an impact on eutrophication. The problem is, however, that there are insufficient incentives within these sectors to further reduce their contributions to nutrient enrichment of aquatic ecosystems. The hypothesis underpinning the MIRACLE project is that more effective approaches to ’nutrient governance’ cannot focus solely on the nutrient issue itself. Real changes will require bringing on board new constellations of stakeholders with issues that are interconnected with nutrient enrichment. We will seek win-win models for governance by emphasising synergies between aligned policy communities, such as the flood control sector, downstream urban communities vulnerable to flooding, biodiversity conservation interests, and the human health and biosecurity sector.

In this interdisciplinary project, social scientists work with economists and hydrologists in a social learning process with stakeholders. The aim is to identify new configurations for governance (conceptual, institutional and practice based) to reduce nutrient enrichment and flood risks in the Baltic Sea region. An example could be how to reform farming practices in a way that measures such as flood control and biodiversity conservation become new ’agricultural products’ which also impact emissions of nutrients.

A set of workshops will be organised in four case areas, the Berze (Latvia), Reda (Poland), Helgeån (Sweden), and Selke (Germany). Cross-case and regional workshops will facilitate scaling up the results to the Baltic Sea region level. The workshops will identify innovative actions and plans that offer multiple ecosystem service benefits to diverse stakeholders. The social learning process will be supported by interactive hydrological modelling of what impacts the suggested measures will have on nutrient transport and flooding risks. Here, uncertainty assessments and the need for adaptation to climate change scenarios are key features. Economists will assess the cost and benefits of selected governance features and policy instruments in the environmental mitigation and flood prevention scenarios. The goal is to identify the most socioeconomically efficient measures and governance features to deliver multiple ecosystem service benefits.

In the project, an interactive visualisation platform will be used where stakeholders will guide the use of input data sets and the development of visualised scenarios. The aim is to facilitate their understanding of suggested governance actions’ consequences and assist identification of novel actions. Policy analyses will be done to identify how institutional settings have shaped governance structures in the Baltic Sea region. In the next step, opportunities for greater integration of agricultural and environmental policy actions at different scales will be identified. A particular focus will be on identifying prospects for introduction of payments for ecosystem services as a key governance approach. Finally, emerging from the social learning process, to the project aims to support the development of road maps that integrate agricultural, environmental and risk management governance in the Baltic Sea region.

Project partners

Linköping University, Sweden, (coordinating partner)
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3 Cost-Effectiveness Analysis (CEA)

As elaborated in Deliverable 3.4, a cost-effectiveness analysis approach is applied to provide a ranking of the relative performance of different measures, based on their cost and effect for, in this case, mitigating N and P loads to the Baltic Sea (Balana et al., 2011). Assume that there are $i = 1 \ldots n$ measures available, and for each measure C_i represents the costs and E_i the nutrient mitigation capacity in physical units, e.g. kilos of N reduced. The cost-effectiveness ratio CER_i of the measure is then computed as:

$$CER_i = \frac{C_i}{E_i} \quad [1.2]$$

The CER thus expresses the cost per physical unit, e.g. € per kilo N reduced. Calculating the CERs for all the measures of interest enables a direct economic comparison and ranking of the measures. The economic rationale is that decision-makers aiming to reduce a certain amount of e.g. N should then choose the measure(s) with the lowest CERs since they will achieve the reduction at the lowest possible cost. In practice, there may be limits to e.g. the possible scope of measures with the lowest CERs, leading to implementation of also those with higher CERs.

3.1 Costs and annuity

The CEA is based on the cost structures, as itemised in the previous deliverables. While the nutrient mitigation is usually indicated as an annual mitigation rate per measure (cf. section 3.2), the emerging costs of the respective measure are not equally distributed throughout the years of the respective case area pathways[1], e.g. due to one-time implementation costs, but ongoing maintenance costs. The cost therefore needs to be converted into average annual cost by multiplying the present value (formula 1.1) with the annuity factor (formula 1.2). The resulting values show the average annual costs for a defined period[2] in terms of the present value.

$$Present\ Value = \frac{Future\ Value}{(1+r)^t} \quad (1.1)$$

$$Annuity\ Factor = \frac{r}{1-(1+r)^{-n}} \quad (1.2)$$

With
t = time at which the future value occurs
r = social discount rate
n = number of years of the respective pathway

[1] outlined in e.g. deliverable 3.2

[2] as described in previous deliverables, the time frame of the business-as-usual pathways (also called ”pathway 1”) is defined as 2017-2030, while the defined period for the alternative pathways (”pathway 2”, ”pathway 3”, etc.) is 2021-2030. This means that all costs occurring during these periods are taken into account, even though some measures may target a longer time period.

3.2 Nutrient mitigation rate and the HYPE model

The nutrient mitigation rates of N and P that are used in the CEA, are based on the case-specific results of the HYPE (the HYdrological Predictions for the Environment) model simulations for the four case areas, as provided by the MIRACLE work package 2 (D 2.4). The model computes how the implementation of the different measures affects the water flow and the N and P concentrations in the river outflows of sub-basins in the catchments, and also how that is affected by different climate and land-use scenarios. It is a "continuous time, spatially semi-distributed and process-oriented hydrological nutrient transport model" (Jiang et al. 2015, p. 941) and "delineates the whole catchment into sub-basin systems based on the digital elevation model and stream network" (Jomaa et al. 2016, p. 5). Each sub-basin is thereby "divided into different soil-land use combinations (SLCs) by the overlapping soil and land use maps. Each SLC corresponds to a unique hydrological response unit (HRU)" and "is defined as a percentage of the sub-basin area and is not coupled with the geographical location. Different vegetation types, such as forest and crop area, are simulated as separate land uses" and "the soil can be divided into a maximum of three layers, which can be specified with different thicknesses" (Jomaa et al. 2016, p. 5). The sub-basins act as independent catchment reactor, and are hydrologically connected through a routing scheme. Nutrient retention and transformation in groundwater, streams and lakes is simulated in separate routines, which means that the modelled impact of measures depend on where they are implemented in the catchment. A measure implemented in areas close to the river outflow from the catchment will have a larger nutrient removal effectiveness than if the same measure is implemented in upstream sub-basins. When estimating the CER, we have used the effectiveness of a certain measure for the entire catchment, i.e. accounting for the natural retention that takes place and reduces the net effect of a certain measure implemented over the entire catchment. This is discussed more in detail by Arheimer and Pers (2017) for construction and restoration of wetlands in Sweden.

Whenever the modelling results allowed for it, the CER is calculated for single measures under
- current climate and land-use,
- effect of climate change, and/or
- effect of land-use change.

RCP 8.5 is thereby used as the climate change scenario, and SCENAR 2020-II as the future land-use scenario. Further information regarding the HYPE model, the modelling assumptions, and the scenario descriptions can be found in the reports D 2.2 - 2.4.

4 Cost-effectiveness of selected mitigation measures for the case areas

The following Table 1 outlines the main variables and the results of the CEA, as introduced in chapter 3. To calculate the yearly costs, the respective country's recommended social discount rate (cf. section 3.1) is used, namely 2 % for Selke (Albert et al. 2017), 3.5 % for Helge (Swedish Transport Administration 2016) and 5 % for Berze (Ministry of Finance Latvia 2016). Only measures are considered with both 1) available case-specific cost structures and 2) separate[3] and case-specific nutrient mitigation rates for the river outflow from the catchment, as modelled and provided by the researchers in work package 2. The scenarios differ a bit between the catchment, since the case area teams used slightly different modelling approaches. Due to insufficient information and data delivery (e.g. in terms of the measures' costs, scopes or effects under the impact of both climate and land-use change), a CEA of measures selected for the Reda River case area cannot be provided.

As introduced in section 3.2, the nutrient removal effects of the measures (and thus their CER) is calculated for the river outflow from the catchment, i.e. it describes the net effect by taking catchment retention processes into account. Due to such natural retention that takes place in groundwater, lakes and streams, the rates are lower compared to the effects and effectiveness in a local scale where the measures are actually implemented.

In relation to the mitigation of N, the reduced application of mineral fertilizer on arable land appears to be the most cost-effective measure, whereas the establishment of wastewater treatment plants (WWTPs) in Berze reduces P mitigation most cost-effectively. However, while the latter result draws on (i) costs for the establishment of similar WWTPs in Latvia and (ii) the HELCOM recommendation 28E/6 in terms of treatment specifications, the cost-effectiveness may as well change when different costs, plant sizes or more ambitious treatment specifications are assumed or required. The CER of all other measures is higher than the total benefit of a reduced eutrophication, as suggested by HELCOM and NEFCO (2007). Converted to 2016 prices, this value is estimated as being 14 Euro per kg N, and 326 Euro per kg P reduction (cf. deliverable 3.4). Alternatively, Interwies et al. (2013) estimate, based on Söderqvist (1996) and Turner et al. (1999), the Willingness-To-Pay (WTP) for one thousand tons abated N-deposition to be 0.88 Euro per person and year. Depending on the size of the considered population, the total value of nutrient mitigation thus varies (with a 2010 price level). For instance, by using Germany as case example, Interwies et al. (2013) calculate a total benefit as being 58.43 Euro per kg N mitigation (2010 price level). This approach accordingly means that the total benefit per kg nutrient mitigation can be much lower or higher, depending on which population (size) is considered. Furthermore, such values are typically assessed by asking respondents regarding their WTP to achieve a certain state (e.g. by fulfilling the Baltic Sea Action Plan or "reducing the nutrient deposition by 50 %"), whereas the result is subsequently converted to "per kg" values. However, the wtp-rate depends on various factors and variables and is not consistent across regions (see e.g. Ahtiainen et al., 2014). The interpretation of such prices should therefore be handled with care and rather understood as a guiding value, yet not as the ultimate decision criterion if a measure can be considered as cost-effective or not.

[3] i.e. nutrient mitigation rates of measure bundles (e.g. pathways) are not included

Table 1 Cost-Effectiveness of selected mitigation measures (at the river outflow)

Measure (i)	Scenario	Nutrient mitigation rate (E)		Costs (C)	Cost-Effectiveness Ratio (CER)	
SELKE RIVER CATCHMENT		N reduction in kg/ha/y	P reduction in kg/ha/y	Yearly Costs in EUR/ha	EUR per 1 kg N mitigation	EUR per 1 kg P mitigation
Buffer strips (10m)	Current climate and land-use	0.00	0.03	503.20	-	17,603.64
	RCP 8.5 and SCENAR 2020-II	0.00	0.06	503.20	-	8,128.85
Buffer strips (20m)	Current climate and land-use	0.00	0.03	503.20	-	14,676.12
	RCP 8.5 and SCENAR 2020-II	0.00	0.13	503.20	-	3,941.75
Contour ploughing	Current climate and land-use	0.00	0.02	cost neutral	-	0.00
	RCP 8.5 and SCENAR 2020-II	0.00	0.08	cost neutral	-	0.00
20% reduction of N mineral fertilizer	Current climate and land-use	0.57	0.00	-5.03	-8.85	-
	RCP 8.5 and SCENAR 2020-II	0.81	0.00	-5.03	-6.22	-
HELGE RIVER CATCHMENT		N reduction in kg/km/y	P reduction in kg/km/y	Yearly Costs in SEK/km	SEK per kg N mitigation	SEK per 1 kg P mitigation
Meandering	RCP 8.5 and current land-use	36.36	0.00	104,608.77	2,877.03	-
	RCP 8.5 and SCENAR 2020-II	30.30	-0.06	104,608.77	3,452.43	n.a.
		N reduction in kg/ha/y	P reduction in kg/ha/y	Yearly Costs in SEK/ha	SEK per kg N mitigation	SEK per 1 kg P mitigation
Riparian zones in agriculture	RCP 8.5 and current land-use	0	0.05	5,947.50	-	118,950.00
	RCP 8.5 and SCENAR 2020-II	0	0.05	5,947.50	-	118,950.00
Stormwater ponds	RCP 8.5 and current land-use	65.15	5.86	279,997.37	4,297.73	47,781.12
	RCP 8.5 and SCENAR 2020-II	65.15	5.86	279,997.37	4,297.73	47,781.12
Wetlands	RCP 8.5 and current land-use	19.25	0.95	26,670.72	1,385.49	28,074.44
	RCP 8.5 and SCENAR 2020-II	17.58	0.93	26,670.72	1,517.11	28,678.19
BERZE RIVER CATCHMENT		N reduction in kg/ha/y	P reduction in kg/ha/y	Yearly Costs in EUR/ha	EUR per kg N mitigation	EUR per 1 kg P mitigation
Crop rotation	Current climate and land-use	-0.02	0.00	59.65	n.a.	62,789.47
Organic farming	Current climate and land-use	0.22	0.00	59.65	272.18	31,230.37
Buffer strips (2+5 m)	Current climate and land-use	0.00	0.56	259.15	-	459.75
Buffer strips (2+10 m)	Current climate and land-use	0.00	0.68	259.15	-	381.64
20% reduction of mineral fertilizer application	Current climate and land-use	2.68	0.00	133.58	49.93	55,891.21
		N reduction in kg/plant/y	P reduction in kg/plant/y	Yearly Costs in EUR/plant	EUR per kg N mitigation	EUR per 1 kg P mitigation
Municipal Wastewater Treatment Plants (100 – 300 PE)[4]	Current climate and land-use	229.16	61.25	15,520.98	67.73	253.40

[4] The treatment level of the newly established WWTPs is assumed to follow HELCOM recommendation 28E/6 (adopted on November 15th 2007) which requires on-site wastewater treatment plants of up to 300 person equivalents to meet certain wastewater treatment specifications with respect to BOD5 (20 mg/l), total phosphorus (5 mg/l) and total nitrogen (25 mg/l).

Based on comparable literature, it is evident that the cost-effectiveness of measures differs significantly across regions. In BalticSTERN (2013), for instance, Ahlvik et al. (2014) estimate the CER of small scale wastewater treatment in the Baltic Sea Region to be between 2 - 642 Euro for mitigating 1 kg N, and 10 – 2,772 Euro for mitigating 1 kg P, whereas Hasler et al. (2012) estimate the rate to be between 14.6 – 13,898 Euro for N and 57 – 537 Euro for P. While the numbers in both models refer to the reduction "at sea" and are therefore in this regard comparable to the results within this report (table 1), the underlying models and variables, such as the reduction potential, vary (cf. Ahlvik et al., 2014; Hasler et al., 2012). Moreover, the high interval in both assessments might be due to both the different local conditions, methodological assessments and types of WWTPs (e.g. in terms of size and treatment specifications).
One example of a highly case-specific outcome is the measure "reducing fertilizer application" in the Selke catchment. The saved costs of fertilizer in that catchment outweigh the loss due to the consequential yield reduction, which results in a negative CER. This means that the landowner theoretically gains money per kg mitigated N. One reason could be the highly fertile soil ("Börde") in that area, which results in high yields, even with lower fertilizer input. As a comparison, Gren et al. (2008) estimate the cost-effectiveness of fertilizer reduction to be between 1 - 44 Euro per kg mitigated N in Germany, and 1 – 17 Euro in Latvia, whereas the models of Ahlvik et al. (2014) and Hasler et al. (2012) assess the CER to be between 2 – 158 and 0.5 – 8 Euro per kg mitigated N respectively (for the Baltic Sea region and at sea). These outcomes underline the importance of considering both the local context and any model assumptions, which result in a difficulty of using numbers in a different setting. An estimated CER for a certain measure in one catchment might not be valid in another setting. This needs to be considered when measures or models are upscaled, for instance to the entire Baltic Sea region.

5 CEA as a social learning tool

Since the pathways of the different case areas generally consist of a fixed bundle of measures, a ranking based on the CER is rather redundant. However, the information on the cost-effectiveness provides valuable input to the stakeholder workshops, especially when considering the high CERs of most of the measures. The CEA was particularly used to highlight and stimulate the discussions regarding the importance of considering multiple benefits of certain measures beyond their impact on nutrient mitigation only (in terms of the respective rivers' outflow). The presentation of the cost-effectiveness of a measure was thereby followed by outlining its possible delivery of other ecosystem services. For instance, the CER of buffer strips (2+5 m) in the Berze river catchment is estimated to be 459.75 Euro per kg P mitigation (Table 1). However, Table 2 indicates that nutrient mitigation is only one of many possible benefits of such a measure.

Table 2 Ecosystem Service Matrix for Buffer Strips (Berze catchment)

Section	Group	Impact Rating
PROVISIONING SERVICES	Economically more efficient/ viable agriculture	None
PROVISIONING SERVICES	Increased quality of food	None
PROVISIONING SERVICES	Improved surface and groundwater quality	Moderate
PROVISIONING SERVICES	*OVERALL RATING*	*LOW*
REGULATING AND MAINTENANCE SERVICES	Increased water infiltration, runoff attenuation - reduce peak flow/ risk of flooding	Moderate
REGULATING AND MAINTENANCE SERVICES	Increased soil fertility - improved soil structure and organic	Low
REGULATING AND MAINTENANCE SERVICES	Increased carbon sequestration	Moderate
REGULATING AND MAINTENANCE SERVICES	Prevention of soil erosion/ sediment transport	High
REGULATING AND MAINTENANCE SERVICES	*OVERALL RATING*	*MODERATE*
HABITAT SERVICES	Increased riparian/terrestrial biodiversity, biotopes and improved grasslands habitats	High
HABITAT SERVICES	Improved aquatic habitats	High
HABITAT SERVICES	*OVERALL RATING*	*HIGH*
CULTURAL SERVICES	Increased landscape heterogeneity	Moderate
CULTURAL SERVICES	Improved recreation activities	Moderate
CULTURAL SERVICES	Increased opportunities for tourism, eco-tourism and tourism support services	Low
CULTURAL SERVICES	*OVERALL RATING*	*MODERATE*

Source: WP2 presentation at the Berze Stakeholder Workshop, June 2017; the preliminary rating was provided by MIRACLE case study partners from the Berze case study area as an input to the workshop discussions. The full ranking possibilities consist of "high", "moderate", "low", "non/negligible" and "negative".

6 Concluding remarks

This report outlines the cost-effectiveness of selected nutrient mitigating measures, based on the so far assessed cost structures and the currently available modelling results from the HYPE model provided by work package 2. When compared to assessments in terms of total benefits of a reduced nutrient deposition, this analysis results in predominantly high CERs, meaning that measures mitigate nutrients in a rather costly way. This underlines the importance of considering the multiple effects of measures, which, as briefly introduced in deliverable 3.4, is often resulting in benefits outweighing their costs. This will be further elaborated upon in the upcoming deliverables 3.6 and 3.7.

Due to the ongoing work of modelling the nutrient mitigating effects of the measures under different land-use and climate scenarios, the CER is calculated only for a limited number of measures under certain scenarios. This deliverable should therefore be regarded as work in progress.

7 Bibliography

Ahlvik, L., Ekholm, P., Hyytiäinen, K., Pitkänen, H. (2014). An economic–ecological model to evaluate impacts of nutrient abatement in the Baltic Sea, In Environmental Modelling & Software, Volume 55, 2014, Pages 164-175, ISSN 1364-8152, https://doi.org/10.1016/j.envsoft.2014.01.027.

Ahtiainen, H., Artell, J., Czajkowski, M., Hasler, B., Hasselström, L., Huhtala, A., ... & Angeli, D. (2014). Benefits of meeting nutrient reduction targets for the Baltic Sea–a contingent valuation study in the nine coastal states. *Journal of Environmental Economics and Policy*, *3*(3), 278-305

Albert, C., Schröter-Schlaack, C., Hansjürgens, B., Dehnhardt, A., Döring, R., Job, H., . . . Reutter, M. (2017). An economic perspective on land use decisions in agricultural landscapes: Insights from the TEEB Germany Study. *Ecosystem Services, 25*, 69-78.

Arheimer, B. and Pers, B.C. (2017). Lessons learned? Effects of nutrient reductions from constructing wetlands in 1996-2006 across Sweden. Ecological Engineering 103, 404-414.

Artioli, Y., Friedrich, J., Gilbert, A. J., McQuatters-Gollop, A., Mee, L. D., Vermaat, J. E., Wulff, F., Humborg, C., Palmeri, L., Pollehne, F. (2008). Nutrient budgets for European seas: A measure of the effectiveness of nutrient reduction policies. Marine Pollution Bulletin, 56(9), 1609-1617. doi:https://doi.org/10.1016/j.marpolbul.2008.05.027

Balana, B. B., Vinten, A., & Slee, B. (2011). A review on cost-effectiveness analysis of agri-environmental measures related to the EU WFD: Key issues, methods, and applications. Ecological Economics, 70(6), 1021-1031.

BalticSTERN (2013). Costs of mitigating eutrophication. Background Paper. Havs- och vattenmyndighetens rapport 2013:4.

Gren, I.-M., Jonzon, Y., Lindqvist, M. (2008): Costs of nutrient reductions to the Baltic Sea - technical report. Swedish University of Agricultural Science. Uppsala.

Hasler, B., Smart, J.C.R., and Fonnesbech-Wulff, A. 2012. Deliverable 8.1. RECOCA. Stucture of BALTCOST drainage basin scale abatement cost minimization model for nutrient reductions in the Baltic Sea Region.

HELCOM and NEFCO. (2007). Economic analysis of the BSAP with focus on eutrophication. Final report, COWI

Interwies et al. 2013: Methodische Grundlagen für sozio-ökonomische Analysen sowie Folgenabschätzungen von Maßnahmen einschließlich Kosten-Nutzen-Analysen nach EG-Meeresstrategie-Richtlinie (MSRL), Abschlussbericht im Auftrag des Umweltbundesamtes, FKZ 3710 25 202; Interwies, E., Angeli, D., Bertram, C., Dworak, T., Friedrich, R., Görlitz, S., Hiebenthal, C., Kugler, U., Meyerhoff, J., Preiss, P., Rumohr, H., Reumann-Schwichtenberg, J. und K. Rehdanz.

Jiang S., Jomaa S., Büttner O., Günter M., Michael R. (2015) Multi-site identification of a distributed hydrological nitrogen model using Bayesian uncertainty analysis. J Hydrol 529:3. doi:10.1016/j.jhydrol.2015.09.009

Jomaa, S., Jiang, S., Thraen, D., Rode, M. (2016). Modelling the effect of different agricultural practices on stream nitrogen load in central Germany. Energy, Sustainability and Society (2016) 6:11 DOI 10.1186/s13705-016-0077-9

Kiedrzyńska, E., Kiedrzyński, M., Urbaniak, M., Magnuszewski, A., Skłodowski, M., Wyrwicka, A., Zalewski, M. (2014). Point sources of nutrient pollution in the lowland river catchment in the context of the Baltic Sea eutrophication. Ecological Engineering, 70, 337-348. doi:https://doi.org/10.1016/j.ecoleng.2014.06.010

Ministry of Finance Latvia. (2016). Makroekonomisko pieņēmumu un prognožu skaitliskās vērtības. Retrieved from http://www.fm.gov.lv/files/publiskaprivatapartneriba/2016-09-12_12_06_37_160711_info_ES%20FEA.pdf

Söderqvist (1996). The Benefits of a less Eutrophicated Sea. Beijer discussion paper series No. 88, Beijer international institute of environmental economics, Stockholm.

Swedish Transport Administration. (2016). Analysmetod och samhällsekonomiska kalkylvärden för transportsektorn: ASEK 6.0. Kapitel 20 English summary of ASEK Guidelines. Version 2016-04-01.

Turner, R.K., Georgiou, S., Gren, I.-M., Wulff, F., Barrett, S., Söderqvist, T., Bateman, I., Folke, C., Langaas, S., Zylicz, T., Mäler, K.-G. and A. Markowska (1999). Managing nutrient fluxes and pollution in the Baltic: an interdisciplinary simulation study. Ecological Economics, 30: 333-352