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COST EFFECTIVENESS AND FAIRNESS OF THE HELCOM BALTIC SEA ACTION PLAN AGAINST EUTROPHICATION

Kostnadseffektivitet och rättvisa i Helcoms aktionsplan för minskad övergödning i Östersjön

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Abstract

This paper evaluates the Baltic Sea Action Plan (BSAP) proposed by Helcom (Helsinki Commission) to combat eutrophication in the Baltic Sea with respect to cost effectiveness and fairness. The background is the documented needs of both these factors for truthful implementation of international agreements, such as the ministerial adoption of BSAP in autumn 2007. The fairness criteria included in this study rest on egalitarian and capability principles and relate nutrient loads and abatement costs to population and GDP (gross domestic production). The results indicate that the cost of BSAP is almost 40 per cent higher than necessary, and that its implementation increases the difference among countries with respect to nutrient loads related to population and GDP. Furthermore, the cleaning cost burdens are relatively high for countries with low GDP per capita. Unless BSAP country allocation undergoes changes there is a risk for implementation failure similar to that of the ministerial agreement on nutrient reductions from 1988, which today is far from being reached in practice.

Key words – eutrophication, Baltic Sea, Helcom BSAP, cost effectiveness, fairness, evaluation

Sammanfattning

Syftet med denna studie är att utvärdera Helcom's (Helsingforskommissionen) förslag till fördelning av rening mellan olika länder runt Östersjön (BSAP) för att motverka eutrofiering med avseende på kostnadseffektivitet och rättvisa. Förslaget godtogs vid ett ministermöte under hösten 2007, men sannolikheten är stor att det inte genomförs i praktiken om det inte uppfattas som rättvist och kostnadseffektivt. Resultaten i denna studie pekar på att fördelningen av rening i BSAP inte uppfyller något av dessa krav. En jämförelse med en kostnadseffektiv lösning visar att BSAP är ca 40 procent dyrare. Skillnader mellan länder i utsläpp av kväve och fosfor per invånare och per BNP (bruttonationalprodukt) ökar genom införandet av BSAP. Dessutom är reningskostnaderna relativt höga för länder med låg ekonomisk utveckling, mätt i BNP per invånare. Om inte BSAP omprövas är det därför risk att den möter samma öde som ministeröverenskommelsen om utsläppsreduktioner från 1988, som ännu inte uppnåtts i praktiken.

1. Introduction

Damages from eutrophication in the Baltic Sea have been documented since early 1960s by a number of different studies (e.g. Wulff et al. 2001). The riparian countries also showed concern by, among other things, the manifestation of the administrative body Helcom in charge of policies for improving Baltic Sea since 1974, and ministerial agreements in 1988 and 2007 (Helcom 1993; Helcom 2007). However, in spite of the ambitious agreement of reducing nutrient loads by 50 per cent in 1988, long-term monitoring of nutrient transports, political concern, and improved scientific understanding of the functioning of the sea, degradation of the sea continues. Approximately 20 years after the meeting in 1988, the agreed level of nutrient reductions in 1988 is far from being reached. One important reason for the hesitation to reduce nutrient loads to the Baltic

Sea is by all likelihood associated costs, which now start to increase at a higher rate than earlier since the low cost options, such as improvement in nutrient cleaning at sewage treatment plants located at the coastal waters of the Sea, have been implemented in several countries. Therefore, careful cost calculations are now likely to be more important than earlier. Furthermore, a successful implementation of an international agreement requires a perception of fairness by involved stakeholders (e.g. Carraro, 2000; Bérubé and Cusson, 2002; Lange et al. 2007). The purpose of this study is to evaluate whether or not the ministerial agreement in autumn 2007 on nutrient reductions to the Baltic Sea, the Helcom Baltic Sea Action Plan (BSAP), meets the conditions of cost effectiveness and fairness.

Although there is a large literature on cost effective achievements of international environmental agreements, there are few studies considering this together with fairness outcomes. Such evaluations of international agreements have been made mainly for energy policies (e.g. Carraro and Busner, 2002; Lange 2007; Dannenberg, 2008). A typical approach has then been to calculate impacts of mitigation strategies and to assess dispersion of costs and benefit among different countries under different rules of fairness. There are several studies calculating costs of nutrient reductions to the Baltic Sea (see Elofsson 2008 for a review). Studies relating cleaning costs to associated dispersal of benefits among countries are lacking. The approach used in this study is therefore to compare costs of the BSAP with a cost effective solution, and to assess outcomes under BSAP with respect to different fairness criteria. The chosen criteria are nutrient loads and cleaning costs related to population and gross domestic product (GDP).

The paper is organised as follows. First a brief presentation of the Helcom BSAP is given. This is followed by a conceptual discussion of cost effectiveness and fairness. The model for calculating cost effective solutions is presented in Chapter 3, and the results with respect to evaluation of BSAP are shown in Chapter 4. The paper ends with a brief summary and some tentative conclusions.

Table 1. *BSAP nutrient reductions for riparian countries, in %.*

	Nitrogen	Phosphorus
Denmark	31	35
Estonia	5	22
Finland	8	25
Germany	29	41
Latvia	25	34
Poland	30	68
Sweden	29	39
Russia	8	38
Lithuania	27	65
Total, %	25	54

Source: Helcom (2007) pp. 3.

2. Brief presentation of the Helcom BSAP against eutrophication

Nutrient enrichment and unbalanced loads of nitrogen and phosphorus contribute to blooms of toxic algae, and oxygen deficits (e.g. Wulff et a., 2001). In Helcom (2007), the following nutrient related ecological objectives have therefore been suggested

– concentration of nutrients close to natural levels,
– clear water,
– natural level of algal blooms,
– natural distribution and occurrence of plants and animals,
– natural oxygen level.

Conditions for the achievements of these targets differ among different parts of the Baltic Sea, but it is regarded that reductions in nutrient loads improve water quality in most parts of the Sea. In autumn 2007, the riparian countries adopted an action plan, the Helcom BSAP, in order to reduce nutrient loads to the Sea. According to the action plan, phosphorus reductions are required to Baltic Proper, Gulf of Finland and Gulf of Riga, and nitrogen reductions to Baltic Proper, Danish straits and Kattegat. Phosphorus reductions, as measured in percent reductions from initial modelled loads, are largest for the Baltic Proper, and the largest nitrogen reductions are needed for Kattegat and the Danish Straits. It is predicted that these reductions will reduce the extension of hypoxic sea bottoms in the Baltic Proper by approximately 1/3, and nitrogen fixation, an indicator of the intensity of cyanobacterial blooms, is expected to decrease by 2/3.

The targets of maximum nutrient loads to the marine basins of the Baltic Sea are translated into required nitrogen and phosphorus reductions by countries as presented in Table 1.

The reductions are to be implemented at the latest in 2021, and each country is supposed to present a plan for reaching the reduction in 2010. According to the agreement, each country can design national cost effective cleaning programs. The BSAP also specifies measures to be part of each country's program; increased cleaning of phosphorus at sewage treatment plants, phosphate free detergents, and drastic nutrient reductions by the agricultural sector.

3. Cost effectiveness and fairness – a simple analytical framework

There is an emerging literature in economics on the role of cost effectiveness and fairness for agreements on international environmental problems (e.g. Carraro, 2000; Bérubé and Cusson, 2002; Lange et al. 2007). The general approach is to treat the two issues separately by first identifying efficient cleaning allocations and then carry out an assessment with respect to different fairness criteria. This approach is also applied in this paper, where we first discuss conditions for cost effectiveness and then present fairness criteria.

Cost effectiveness is defined as the allocation of abatement measures within and among different countries which generates the predetermined target(s) at minimum overall cost. The condition for this is that marginal costs of all measures are equal. As long as marginal costs differ among measures it is always possible to reallocate abatement and obtain the same target at a lower cost. This is made by reducing cleaning by the relatively high cost measure and increasing it by the same amount by the low cost measures. Starting with the cost for a single country, say Poland, it is assumed that it chooses the minimum cost for each level of cleaning. It then becomes increasingly more costly to clean up at higher cleaning levels. Such a typical shape of the so called marginal cost for cleaning is illustrated in Figure 1.

The MC^{Pol} curve in Figure 1 illustrates how the cost for an additional cleaning of phosphorus is increasing at higher cleaning levels. Each point on the curve shows the minimum cost for an additional cleaning by one ton. It is then assumed that the country uses its resources for cleaning, such as labour and capital, in order to minimise total cleaning cost at each cleaning level. If this is not the case, such as under the requirement of best available technology, the marginal cost becomes higher.

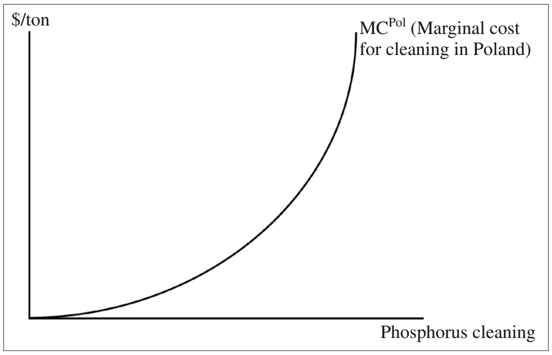

Figure 1. *Illustration of marginal cleaning cost of phosphorus for a country, Poland.*

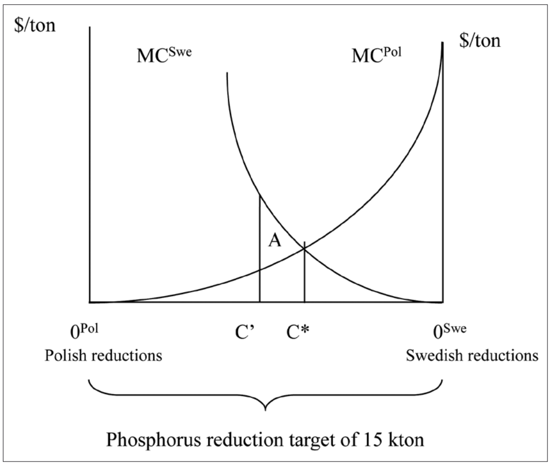

Figure 2. *Illustration of cost efficient cleaning between two countries, Poland and Sweden. (MC^{Pol}: marginal cleaning cost in Poland, MC^{Swe}: marginal cleaning cost in Sweden, 0^{Pol}: no cleaning in Poland, 0^{Swe}: no cleaning in Sweden, C*: cost effective cleaning allocation, C': uniform cleaning allocation, area A: losses, increases in total cleaning cost, of allocation at C' instead of at C*).*

Each riparian country faces a marginal cost function in cleaning, the shape of which is similar to that in Figure 1 but with different slopes showing the rate at which the marginal cost increases. For illustrative purposes, let us assume that the total BSAP phosphorus requirement of approximately 15 000 tons can be achieved by two countries, Poland and Sweden, and the question is then how to allocate cost effective cleaning between these two countries. The answer to this question is illustrated in Figure 2.

The marginal cleaning cost in Poland, MC^{Pol}, shows the cost of a ton of additional cleaning starting at 0^{Pol} when there is no cleaning. If Poland carries out all cleaning, total cost would correspond to the area under the entire MC^{Pol} curve. In this case there is no cleaning in Sweden. However, by increasing cleaning in Sweden from 0^{Swe} and reducing corresponding level of cleaning in Poland costs can be saved since marginal cost in Sweden is lower than that in Poland. Cost savings can be made as long as $MC^{Swe} < MC^{Pol}$, which occurs at cleaning levels between C^* and 0^{Swe}. At C^*, $MC^{Swe} = MC^{Pol}$ and no cost savings can be made from reallocating cleaning between Poland and Sweden. Corresponding minimum costs are the sum of areas under MC^{Pol} between 0^{Pol} and C^*, and under the MC^{Swe} curve between 0^{Swe} and C^*. Any cleaning allocation other than C^* results in excess cleaning costs, such as the uniform, or equal, cleaning allocation at *C'*, where the excess costs correspond to area *A*.

Whether or not the BSAP country allocation plan as presented in Table 1 is cost effective depends on the marginal cleaning costs for different countries. If marginal cleaning costs differ at the BSAP allocation, it is not cost effective. Corresponding losses from excess costs depend on the differences in marginal cleaning costs for the countries, the higher the difference the larger is the efficiency loss (see Gren and Scharin 2006 for a review).

However, a divergence of BSAP allocation from the cost effective solution might be justified on fairness grounds. Cost effectiveness in a Baltic Sea perspective implies that relatively much cleaning is carried out in countries with access to low abatement costs. Due to difference in factor prices such as labour and land, the costs of abatement measures are low in countries such as Poland, Latvia, Lithuania, Estonia and Russia. If also the impact of measures located in the drainage basins is high due to much leaching from nutrient deposition and transports into the Baltic Sea, the cost effective allocation will result in relatively high cleaning cost burdens in these countries. In general, such a cost burden is regarded as unfair (e.g Grasso, 2007).

Although there is a general consensus on the requirement of fairness for truthful implementation of cleaning plan, there is less agreement on the operational definition of fairness. Usually, a distinction is made between the processes of reaching agreements and the outcome of the agreements (e.g. Carraro, 2000; Grasso, 2007). This paper focuses on fairness with respect to outcomes. In general, two principles can then be distinguished; egalitarian and equity. The egalitarian principle rests on equal human rights, where citizens have the right to, for example, the same amount of emission of nitrogen and phosphorus. The equity principle, based on the capability approach suggested by Sen (1999), relates burdens of actions to the agents' ability to meet them. Based on these two principles of fairness with respect to allocation of cleaning among countries, fairness of BSAP country allocation is assessed according to four different criteria:

– loads of nitrogen and phosphorus per capita
– cleaning cost per capita
– loads of nitrogen and phosphorous in relation to gross domestic product (GDP)
– cleaning cost in relation to gross domestic product (GDP)

The first criterion relies on equal nutrient loads rights, and the second on equal cost burden duties. The third and fourth criteria are related to equity by relating nutrient loads or abatement cost to the affordability of countries, which is measured as their values of total production in the economy, gross domestic product. Similar criteria are adopted in Carraro and Buchner (2002) when assessing equity outcomes from cost effective climate change policies.

4. Brief description of the Baltic Sea cost minimisation model

Costs of abatement measures implemented in any of the drainage basins of the Baltic Sea are determined by their impacts on the target for the Baltic Sea and on the abatement cost at the location of the measure. Impacts of measures implemented in the catchment depend on nutrient transports in the drainage basins, which, in turn, are determined by emissions from sources, leaching and retention during transports from the source to the coastal waters. Since these transport factors differ among different regions in the drainage basin of the Baltic Sea because of variation in climatic, hydrological, and biological conditions, the entire basin is divided into 24 drainage basins with nutrient loads into one of the marine basins. Nutrient transports from sources and costs of abatement measures are calculated for each of these drainage basins, which are briefly presented in this chapter. Unless otherwise stated, all data and calculations are found in Gren et al. (2008a).

Nutrient loads to the Baltic Sea are, for all emission sources, calculated by means of data on emissions, which is sufficient for sources with direct discharges into the Baltic Sea, such as industry and sewage treatment plants located by the coast and air deposition. For all other sources further information is needed on the transformation of nutrients from the emission source to the coastal waters. This requires data on transports of airborne emissions among drainage basins, leaching and retention for all sources with deposition on land within the drainage basins, and on nutrient retention for upstream sources with discharges into water streams. Nitrogen loads are therefore divided into three main classes; airborne emissions, agricultural loads, and discharges of sewage from households and industry. Phosphorus loads are classified into the same categories with the exclusion of airborne emissions.

Airborne emissions include nitrogen oxides and ammonia which are deposited in the drainage basins and directly on the Baltic Sea. This study includes all air deposition on land within the drainage basin, which originates from countries within and outside the drainage basin, which can be affected by abatement measures in the drainage basin or coastal waters. This is not the case for direct air deposition on the open sea originating from non-riparian countries, which accounts for approximately 5 per cent of total load to the Baltic Sea (Gren et al., 2008a). The airborne emission gives rise to deposition directly on the Sea and also indirectly through deposition on land, which is transported by soil and water into the Baltic Sea. Calculation of indirect air deposition and loads from agriculture is made by data on airborne transports of nitrogen and ammonia among countries, deposition on land and on leaching from soil and retention in water transports to the Baltic Sea.

The contribution of nutrient loads to the Baltic Sea from arable land is calculated in the same way as for indirect air deposition. Deposition of nutrients on arable land then includes manure and fertilisers. Estimation of discharges of nutrients from households are based on annual emission per capita in different regions, and on connections of populations to sewage treatment plants with different cleaning capacities. It is assumed that remaining nutrients from households and industry in the drainage basins are discharged into water streams, and the final deposition into the Baltic Sea then depends on nutrient retention. Given all assumptions, the calculated total nutrient loads of approximately 830 kton of nitrogen and 40 kton of phosphorus come relatively close to the estimates obtained in Helcom (2004).

The cost minimization model includes 13 different measures for nitrogen reduction and 11 abatement measures for phosphorous reductions. Since the agricultural sector accounts for approximately 60 percent and 50 percent of nitrogen and phosphorus loads respectively, the majority of the measures affect this sector. The model includes the same measures as in BSAP but extends on it by also including measures against airborne emissions and mussel farming as a cleaning device, see Table 2 for a list of included abatement measures.

For each abatement measure, costs are calculated which do not include any side benefits, such as provision of biodiversity by wetlands. Furthermore, abatement measures located in the drainage basins may have a positive impact on water quality, not only in the Baltic Sea, but also in ground and surface waters. However, such data on side benefits are not available for the included abatement measures. This implies an overestimation of abatement costs of measures implemented in the drainage basins. On the other hand, the cost estimates do not account for dispersion of impacts on the rest of the economy from implementation of the measure in a sector, such as possible increase in prices of inputs of a simultaneous implementation of improved cleaning at sewage treatment plants.

The model applies two methods for estimation of costs of the different abatement measures – partial equilibrium and engineering methods – which differ with respect to consideration of affected sectors' actual behaviour in the market. Partial equilibrium analysis is applied for calculations of farmers' costs of reductions in fertilisers, which rests on revealed behaviour on the fertiliser market. Data on prices and purchases of fertiliser can then be used for deriving costs of fertiliser reductions, which correspond to farmers' associated losses in profits. Market prices are also used for assessing costs of conversion of arable land into less leaching land uses such as wetlands and buffer strips. However, there is not enough data to evaluate the effect of massive land conversion on the market price of arable land, and constant prices of land are assumed for the cost calculations. Due to lack of data, constant unit abatement costs are as-

Table 2. *Abatement measures included in the cost minimisation model.*

N reduction (13 measures)	P reduction (11 measures)
Selective catalytic reduction (SCR) on power plants	
SCR on ships	
SCR on trucks	
Reductions in cattle, pigs, and poultry	Reductions in cattle, pigs, and poultry
Fertilizer reduction	Fertilizer reduction
Increased cleaning at sewage treatment plants	Increased cleaning at sewage treatment plants
Private sewers	Private sewers
	P free detergents
Catch crops	Catch crops
Energy forestry	Energy forestry
Grassland	Grassland
Creation of wetlands	Creation of wetlands
Changed spreading time of manure	
	Buffer strips
Mussel farming[1]	Mussel farming[1]

Source: Gren et al. (2008a),
1. Mussel farming cost data in Gren et al. (2008b).

sumed for all other abatement measures except for reductions in fertilisers.

Marginal costs of abatement measures in the drainage basins are calculated by combining estimated costs of cleaning measures with data on impact on the Baltic Sea, which occurs by nutrient transports in air, soil and water. Measures affecting airborne emission have the most involved 'chain of impacts' with both direct and indirect impacts on the Sea. The direct impacts consist of reductions in airborne deposition on the Sea, and the indirect impacts occur through decreases in dispersal of deposition on land within the entire drainage basin, which, in turn, generate less leaching and final transport to the Baltic Sea. Measures with direct impact on the Sea, such as increased cleaning at sewage treatment plants located by the coast, have the most simple 'chain of impacts', where the impact on the Sea corresponds to the reduction at the source. Each abatement measure is also subjected to capacity constraint, such as a maximum cleaning of phosphorus at sewage treatment plant by 90 per cent. Additional constraints consist of the number of households that can be connected to sewage treatment plants. Limitations on fertiliser and livestock reductions and land use changes are imposed in order to avoid drastic structural changes in the agricultural sector. For a detailed presentation of abatement capacities and costs of all measures see Gren et al. (2008a).

In order to account for differences in purchasing power among countries, cost estimates and GDP are adjusted by the purchasing power parity (PPP) index and measured in international dollars, I$, where 1 USD=1 I$. The PPP index reflects the purchasing power of a dollar in each country, and varies between 0.7 and 1.9. This adjustment implies an increase of costs in countries with PPP>1 and a downward adjustment when PPP<1. The GAMS programming code is used for calculating minimum cost solutions under different scenarios (Rosenthal, 2008).

5. Evaluation of BSAP

Evaluation of BSAP with respect to cost effectiveness is carried out by imposing the country cleaning requirements as presented in Table 1 in the cost minimisation model and to compare marginal cleaning costs for nitrogen and phosphorus among countries at the allocation level. It is then assumed that each country implements its cleaning requirement cost effectively. In case of divergence in marginal cleaning costs, the overall reduction of nitrogen and phosphorus, 25 and 54 per cent respectively, can be reached at a lower cost. As reported in Table 3, total costs of the BSAP can be reduced by approximately 25 per cent if a cost effective cleaning allocation is chosen.

As shown in Table 3 there is a considerable difference between marginal cleaning costs of phosphorus, which is more than ten times higher in Poland than in Denmark. Note also that marginal cleaning costs of nitrogen are zero for three countries, Latvia, Poland, and Lithuania. The reason is the relatively modest nitrogen reduction requirement as compared to phosphorus reductions, and/or access to multifunctional low cost abatement measures such as wetlands and mussel cultivation. These measures exhibit simultaneous cleaning capacity of both nutrients.

However, although all countries together gain from cost savings in a cost effective solution as compared with

Table 3. *Evaluation of Helcom BSAP with respect to cost effectiveness, international dollars[1] (I$) per year.*

Country	Marginal cost at BSAP country allocation, I$/kg		BSAP costs, millions of I$	Cost effective solution, millions of I$	BSAP excess cost,	
	N	P			millions of I$	I$/capita
Denmark	16.8	67	125	104	21	5
Estonia	0.9	111	26	171	–145	–108
Finland	0.3	147	32	103	–71	–13
Germany	5.4	105	55	17	38	11
Latvia	0.0	343	165	223	–58	–25
Poland	0.0	840	4304	2682	1622	43
Sweden	9.7	76	109	106	3	0
Russia	0.6	322	213	266	–53	–6
Lithuania	0.0	804	490	350	140	41
Total	0–17	67–840	5521	4022	1499	20

1. Costs are adjusted by the purchasing power parity index for each country.

Table 4. *Nitrogen (N) and phosphorus (P) loads to the Baltic Sea, gross domestic product(GDP)/capita and nitrogen loads and phosphorus loads per GDP in the reference case (without nutrient reductions).*

Country	N load, kg/capita[1,2,3]	P load, kg/capita[1,2,3]	GDP[4], 1000 I$/capita	N/GDP, kg/1000 I$	P/GDP, kg/1000 I$
Denmark	10	0.23	36	0.26	0.006
Estonia	42	1.16	19	2.26	0.063
Finland	9	0.30	33	0.28	0.009
Germany	13	0.12	32	0.40	0.004
Latvia	20	1.26	15	1.28	0.082
Poland	9	0.53	15	0.60	0.036
Sweden	8	0.17	34	0.24	0.005
Russia	10	0.48	13	0.79	0.037
Lithuania	27	0.82	15	1.78	0.053
Mean	11	0.48	20	0.54	0.024
Standard deviation	12	0.43	9	0.74	0.029
Coefficient of variation	1.1	0.9	0.5	1.4	1.2

1. Total population from http://unstats.un.org/unsd/snaama/SelectionQuick.asp, date of access June 20.
2. Drainage basin population shares of total population from Gren et al. (2008a).
3. Initial nutrient loads from Gren et al. (2008a).
4. GDP at PPP from https://www.cia.gov/library/publications/the-world-factbook, date of access June 30.

the BSAP allocation, single countries may face net losses. This occurs for countries with relatively low marginal costs which clean more in the cost effective solution than in the BSAP allocation. In the cost effective solution, the marginal costs are 0.7 I$/kg nitrogen reduction and 371 I$/kg phosphorus reduction. Countries with marginal costs exceeding these cost effective marginal costs gain from a cost effective solution, and vice versa. The largest gain from switching to a cost effective solution is obtained by Poland, where the cleaning cost decrease by 38 per cent or by 43 I$/capita. Estonia faces a significant increase in cleaning costs from such a switch, which corresponds to 108 I$/capita. Sweden is the only country where cost differences under the two regimes are insignificant.

When evaluating fairness with respect to load outcomes as measured per capita or per GDP, it may not be so interesting to compare these outcomes in the BSAP allocation plan, but rather to investigate whether BSAP improves fairness. This is made by comparing nutrient loads prior to cleaning with those resulting from the BSAP. As demonstrated in Table 4, there is a considerable difference among countries before the implementation of BSAP.

According to Table 4, both nutrient loads per capita vary considerably among the countries, Nitrogen loads per capita are lowest for Sweden, Poland and Finland, and phosphorus loads are lowest for Germany, Sweden and Denmark. The differences are explained by different experiences from nutrient cleaning and also by varying hydro-geo-chemical soil and water conditions, which is briefly explained in Chapter 4. Since GDP/capita is high for all these countries except for Poland, the difference in nutrient loads per GDP is increased as compared to loads per capita. This can also be seen from the coefficients of variation, which relate the standard deviation to the mean.

Under the BSAP country allocation, the differences in nutrient load per capita and per GDP are increased, as measured by changes in coefficient of variations, see Table 5.

The increase in differences as measured by coefficients of variation occurs due to the relatively low reduction requirement on countries with large loads per capita, such as Estonia, and high cleaning requirements on countries with relative low kg N/capita, such as Poland. This pattern of change in nutrient loads is similar for P loads per capita, and for N and P loads related to GDP. The annual cleaning cost per capita ranges from 6 I$ (Finland) to 144 I$ (Lithuania). In addition to Lithuania, cleaning costs per capita are above average in Poland and Latvia. When relating this cost to the affordability in the countries, the burden varies between 0.02 % (Finland) and 1.9 % (Lithuania) of GDP.

According to the results presented in Table 5, it thus seems as if the BSAP country allocation does not satisfy any of the fairness criteria applied in this paper. The excess costs as compared to a cost effective solution can

Table 5. *Assessment of BSAP with respect to four fairness criteria.*

Country	Loads, kg/capita		Loads/GDP,		Cleaning cost, I$/capita	Cleaning cost, % of GDP
	kg N	kg P	Kg N/1000 I$	kg P/1000 I$		
Denmark	7	0.15	0.18	0.004	27	0.06
Estonia	40	0.91	2.15	0.049	20	0.18
Finland	9	0.23	0.26	0.007	6	0.02
Germany	9	0.07	0.28	0.002	17	0.05
Latvia	15	0.83	0.95	0.054	72	0.91
Poland	6	0.17	0.42	0.012	113	1.43
Sweden	6	0.10	0.17	0.003	12	0.03
Russia	10	0.30	0.73	0.023	24	0.39
Lithuania	20	0.29	1.30	0.019	144	1.86
Mean	8	0.22	0.41	0.011	72	0.44
Standard deviation	11	0.31	0.66	0.020	50	0.65
Coefficient of variation	1.3	1.4	1.6	1.8	0.7	1.5

then not be justified on the basis of any of the fairness criteria applied in this paper. It is then interesting to note that the cost effective solution reported in Table 2, improves fairness with respect to nutrient loads per capita and per GDP as compared to the reference case, see Table 6.

On the other hand, the cost effective solution implies a larger variation in cleaning cost per capita and in relation to GDP than the BSAP country allocation.

6. Summary and discussion

The purpose of this paper has been to evaluate the Helcom BSAP with respect to cost effectiveness and fairness. Fairness is related to the outcomes of the BSAP, and includes four operational definitions; nutrient load/capita, nutrient load/GDP, cleaning cost/capita, and cleaning cost/GDP. With respect to cost effectiveness, it turned out that the cost of BSAP is almost 40 per cent larger than necessary. However, the allocation of cleaning among countries differs in the two solutions, being higher for Denmark, Germany, Poland, and Lithuania and lower for Estonia, Finland, Latvia, and Russia in the BSAP as compared with the cost effective allocation. The results also indicate that the BSAP does not meet the criteria of fairness as defined by nutrient loads related to population or GDP. The differences in nutrient load per capita and GDP increase as a result of the implementation of the plan. The excess cost can then not be justified on the grounds of fairness criteria applied in this paper. It might be argued that, since the allocation is based on ecological targets in different basins of the Sea, an allocation diverting from that of BSAP will not

Table 6. *Assessment of cost effective solution with respect to different fairness criteria.*

Country	Loads/capita		Loads/GDP,		Cleaning cost, I$/capita	Cleaning cost, % of GDP
	kg N	kg P	Kg N/1000 I$	kg P/1000 I$		
Denmark	9	0.12	0.26	0.003	23	0.05
Estonia	31	0.51	1.67	0.027	128	1.18
Finland	9	0.20	0.26	0.006	20	0.06
Germany	12	0.08	0.38	0.003	5	0.02
Latvia	13	0.63	0.84	0.041	97	1.23
Poland	6	0.23	0.40	0.016	70	0.89
Sweden	8	0.09	0.24	0.003	12	0.03
Russia	8	0.26	0.64	0.020	30	0.48
Lithuania	17	0.33	1.12	0.021	103	1.33
Mean	8	0.22	0.41	0.011	53	0.32
Standard deviation	8	0.10	0.49	0.013	46	0.57
Coefficient of variation	1.0	0.9	1.2	1.2	0.9	1.8

generate the stated ecological targets. However, as shown in Gren (2008) neither BSAP nor cost effective allocation reaches the stated target for the Baltic Proper.

It can then be asked whether or not it is possible to reconcile cost effectiveness and fairness. In principle, this is facilitated by use of economic instruments where incomes from payment for pollution are used for affecting allocation of costs among involved partners (e.g. Carraro, 2000). One of the mechanisms in the Kyoto protocol, the carbon dioxide trading market, can be regarded as an attempt to meet targets of cost effectiveness and fairness. Cost effectiveness is obtained by the establishment of equilibrium permit market price which allocates cleaning to low cost countries. Choice of distribution of initial permits, which implies capital transfers, can be made on equity and fairness grounds. Although much remains to be improved in the international market for carbon dioxide trading, it can be regarded as a success when comparing with agreements and implementation of measures for mitigating eutrophication in international seas surrounded by countries at different development stages, such as the Baltic Sea and the Black Sea. An extension of the Helcom BSAP to allow for nutrient trading may increase the probability of successful implementation of the agreement, and thereby avoiding the same undesirable outcome as that of the ministerial agreement in 1988 which is still far from being reached (Helcom, 1993).

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