PROJECT N. 037033

EXIOPOL

A NEW ENVIRONMENTAL ACCOUNTING FRAMEWORK USING EXTERNALITY DATA AND INPUT-OUTPUT TOOLS FOR POLICY ANALYSIS

DII.2b.-1

External costs of nutrients (N and P) – first estimates

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Report of the EXIOPOL project

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Preamble

This deliverable presents results to be used as basis for the impact-pathway analysis of the external costs of nutrients as applied in agriculture, undertaken in workstream II.2 of the Exiopol project.

Two principal impact pathways have been selected to provide estimates for the external costs as related to the respective effect end-points;

a) Secchi depth changes (water clarity change) as a function of nutrient leaching (N and P) to freshwater lakes and coastal waters, as Secchi depth has been seen to correlate with economic parameters, notably property prices (but also with tourism, biodiversity and further parameters)

b) Nitrate concentration increments in water supply (either from surface water or groundwater) as a function of the application of mineral fertiliser and manure, as a change in nitrate concentration is regarded as a predictor for mortality and morbidity costs linked with suspected changes in cancer rates.

While deliverable DII2A-2 presented the physical modelling framework, this deliverable explores the monetary implications by deriving estimates at catchment level for the external costs per kg N and P applied in agriculture. Subsequently, aggregate external cost estimates can be linked to the economic product categories in the EXIOPOL IO-tables. The present deliverable can be read as a relatively raw data protocol for the calculations performed. A later scientific publication will include more explanations and justifications for the methodology and approaches.

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Executive Summary

1) *Overview*

This report is the report of the EXIOPOL project on valuation and the following calculation of unit values per kg nutrient, all performed using the impact-pathway methodology. The methodology was applied on air pollution in the ExternE project and is here attempted applied on water pollution. The calculations are performed on selected catchments from the Euroharp project.

The whole impact-pathway from application of nutrients to aggregation is outlined in Figure 1. Deliverable DII.2.a-2 covers emission, dispersion and dose-response parts of the impact-pathway, and the final valuation and aggregation used to derive unit values for nutrient application is be presented in this deliverable.

2) *Impact-pathways*

Basically four different impact-pathways as outlined in Figure 1 have been explored.

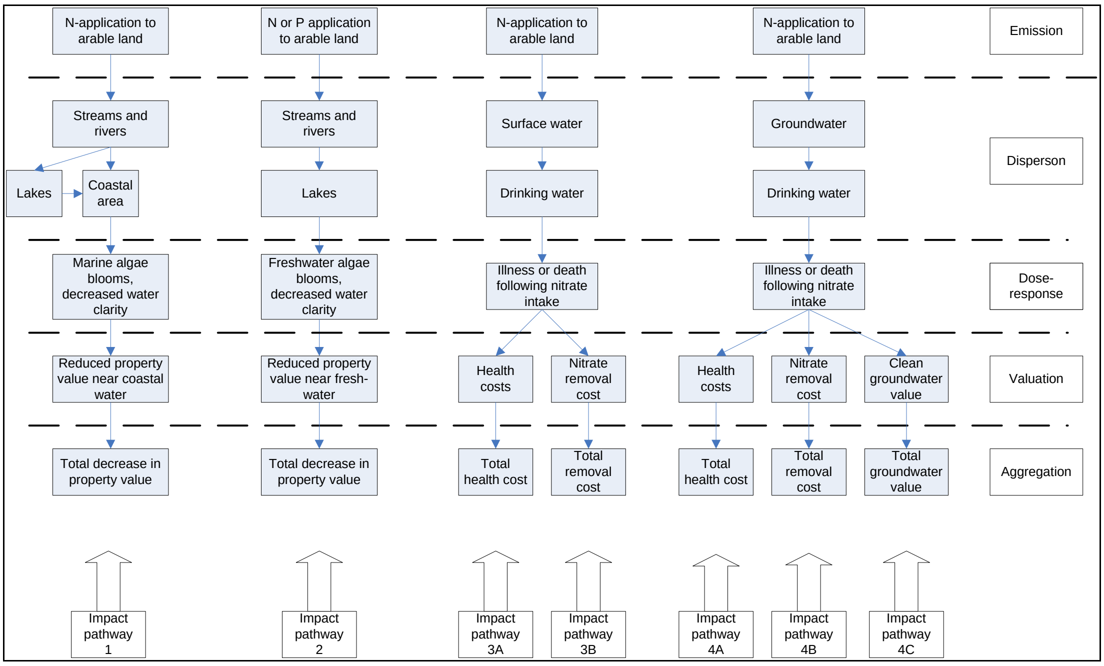

Figure 1: Overview of possible impact-pathways from N application to total affected value.

Below is a brief explanation of the four impact-pathways in Figure 1:

1. Nitrogen is applied on agricultural land and transported to the coastal zone via streams, rivers and lakes, hereby increasing the nutrient concentration in the coastal zone. Algae blooms occur as effect of the increased nutrient concentration and water clarity is reduced. The price of property near the coastal zone is reduced following the decrease in water clarity. The effect is aggregated for the affected coastal zone.

2. Parallel to impact-pathway 1. Phosphorous is applied in agriculture and transported to lakes, hereby causing algae blooms that decrease water clarity. The water clarity decrease affects the property price around lakes.

3. Nitrogen is applied on agricultural land and transported to surface water bodies via streams and lakes. When this surface water is used for drinking water, an increase in cancer rates can occur. The mortality and morbidity costs of the

cancer incidences have been calculated on basis of life-tables reflecting age distribution and cancer rates of the specific catchment population whose water supply stems from surface water bodies (3A). It is preferable to estimate the external costs directly, rather than to rely on abatements costs for nitrate removal (3B).

4. Nitrogen is applied on agricultural land and leaches from the root zone into groundwater aquifers. It depends on the soil type whether nitrate will eventually reach the groundwater; while clayey soils generally offer good condition for redox processes that cause denitrification, groundwater aquifers under sandy soils are more vulnerable to nitrate leaching. If nitrate-contaminated groundwater is extracted for drinking water supply, an increase in cancer rates can occur (see DII2a.-1). The mortality and morbidity costs of the cancer incidences have been estimated on basis of life-tables reflecting age distribution and cancer rates of the specific catchment population whose water supply stems from nitrate contaminated ground water (4A). Abatement costs as mentioned above or associated with relocation of water extraction (4B) or the value of pristine groundwater (4C) can also be used to value the external costs associated with change of the nitrate contents in drinking water, but such approaches are not explored here, as we aim for the first-best external costs.

3) Catchment selection

Six catchments have been selected from the Euroharp project; Odense catchment (Denmark), Zelivka catchment (Czech Republic), Attert catchment (Luxembourg), Enza catchment (Italy), Ouse catchment (England), and Vansjø catchment (Norway). Euroharp catchments in Greece, Spain and Hungary generally suffered from poor data quality, while catchments in Finland, Sweden, France, Austria and Germany were left out in view of the resources available and because the selected six catchments can serve as prototypes for EU-27 as a whole. All six catchments are analyzed with respect to nitrogen and the Vansjø catchment is analyzed with respect to phosphorous. The MyLake model will be used to explore further phosphorous in Odense and Ouse catchments (results to be included in DLII2b-1).

The catchments have been analysed selectively with respect to the relevant impact-pathways. Table 1 provides an overview of the matrix of impact pathway modelling.

Table 1: Selection of impact-pathways. Numbers refer to pathways in Figure 1.

Catchment	Pilot study	Main study
Odense (Denmark)	1	1, 4A
Zelivka (Czech Republic)	3A	3A
Attert (Luxembourg)		4A
Enza (Italy)		4A
Ouse (England)		1, 3A
Vansjø (Norway)		2, 3A

4) Calculations

Each step in the impact-pathway is modelled and providing factors linking one step to the next, basically covering the arrows in Figure 1 crossing the dashed lines. The calculations are described below.

a) Emission-dispersion

Section 3 below presents the modelling results for the increased marginal loads and delta concentrations of nutrients in the recipients per kg applied to agricultural land;

1. Increase in nitrogen (N) load to surface water per kg N applied
2. Increase in phosphorus (P) concentration in surface water per kg P applied
3. Increase in nitrate concentration in surface water per kg N applied.
4. Increase in nitrate concentration in groundwater per kg N applied.

b) Exposure-response

Section 4 below presents the exposure-response relations for the changes in nutrients

1. Change in Secchi depth (water clarity) for a marginal increase in nitrogen concentration.
2. Change in Secchi depth (water clarity) for a marginal increase in phosphorus concentration.

3+4. Change in cancer incidence (mortality and morbidity) for a marginal increase of nitrate in drinking water. (with reference to the review of the literature and evidence in DII2.a.-1).

c) Effect end-point valuation

Monetary valuations of the effect end-points on basis of the physical modelling results in section 4 in deliverable DII.2a.-2 are presented in sections 2 and 3 of this paper. In accordance with the nomenclature of impact-pathways in Figure 1 the impacts are valued as;

1+2. Change in property value per m reduced water clarity, cf. section 2.

3+4. Mortality and morbidity costs per increase in cancer incidence , cf. section 3.

d) Unit values

The emission-dispersion, exposure-response, and effect-valuation steps described above are linked in the aggregation phase in order to arrive at monetary unit values per kg nutrient applied (sections 4 and 5).

$$\frac{N\ concentration\ increase}{kg\ N\ applied} \bullet \frac{reduced\ water\ clarity}{N\ concentration\ increase} \bullet \frac{reduced\ property\ price}{reduced\ water\ clarity} = \frac{reduced\ property\ price}{kg\ N\ applied}$$

$$\frac{N\ concentration\ increase}{kg\ N\ applied} \bullet \frac{increased\ cancer\ mortality}{N\ concentration\ increase} \bullet \frac{value}{increased\ cancer\ mortality} = \frac{value}{kg\ N\ applied}$$

The unit values per kg nutrient applied will in DII2b-2 be used as the basis for splitting the external costs on the different types of agricultural products of the IO-tables, e.g. crops, dairy products and meat.

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1 Introduction

Selected catchments and the external costs of agricultural nutrients are here analyzed according to the impact-pathway methodology, which initially was developed under the ExternE project to estimate the external costs of air pollution. The present results are to our knowledge the first attempt to apply the methodology to nutrients and water pollution. We include some key effect end-points, but do not claim to have covered all relevant effects.

The first part of the impact-pathway modelling was presented in deliverable DII.2.a-2; Part A, "*Impact pathway modelling of agricultural nutrients in six European catchments*", followed by the relevant dose-response calculations for the impact pathways outlined in Figure 1.

This deliverable brings together the different components of the impact pathway sequence to present the first estimates of catchment specific external costs per unit of N and P applied in agriculture.

2 Hedonic valuation, impact-pathway 1 and 2

The impact-pathways and the catchment modelling is presented in the previous deliverable DII2A-2 For Odense and Ouse catchments impact-pathway 1 concerning the impact of nitrogen leaching on change in Secchi depth and ultimately on property values is the relevant effect. For Vansjø catchment impact-pathway 2 concerning the impact of phosphorous on change in Secchi depth and ultimately on property values is the relevant effect.

2.1 House prices as function of water clarity

Several recent hedonic valuation studies indicate how property prices are affected by water clarity (Boyle et al., 1999; Gibbs et al., 2002; Ara, 2007). Boyle et al. (1999) and Gibbs et al. (2002) examine lakefront properties and establish site-specific relationships between Secchi-depth and property values. Many lakes in the study areas (Maine and New Hampshire) are forested, which suggests that it is not the direct visibility of the lake but more the proximity of the lake and the opportunities for associated water activities, e.g. swimming, fishing and boating that is valued. Secchi-depth can be regarded as a proxy for water quality as such. In fact conventional indicators used by biologists, such as the extent of eel-grass, are also closely correlated with Secchi-depth. That non-lakefront properties are also affected by Secchi-depth is established in a comprehensive study of an entire county bordering lake Erie (Ara, 2007)[1].

The Boyle study reflects the boundary condition that at a certain threshold of water clarity a further deterioration has very significant consequences for property values. Furthermore, the study indicates an asymmetric relationship in that the loss associated with a certain *reduction* in water clarity will exceed the gain from an equal *improvement* in water clarity. In our quantitative analysis we abstain from exploring such asymmetries, but its possible existence should be kept in mind when interpreting the estimates. The relationships from (Gibbs et al., 2002) are here applied as a transfer function. The weighted average based on properties in the four housing market areas examined in (Gibbs et al., 2002) indicate a relationship of a 3.3% value loss per full meter of reduction in Secchi depth. We take this central estimate as the starting point for our analysis, but it should be kept in mind that it is based on a variation from 1% to 10% from individual housing areas. While a 3.3% change in property values is substantial it needs to be kept in mind that a full meter of change in Secchi depth is huge and does not appear in any of the scenarios modelled and explored here.

2.2 Odense catchment

GIS maps are used as a basis for the calculations. Coastal waters are defined as extending 500m inland from the shoreline and catchment outlet (Figure 2). The residential zones are related to measuring stations to follow the physical

[1] Following findings in Hasler (2002) we restrict in the analysis here the possible impact to a zone less than 500 meters from the shoreline.

modelling performed and described in chapter 3.2 and 4.1 of deliverable DII2A-2.

The impact on Secchi depth in the canal and inner fjord closer to the catchment outlet has not been included in the analysis, as no response to the change in concentration is expected due to a short residence time combined with an excess of nutrients.

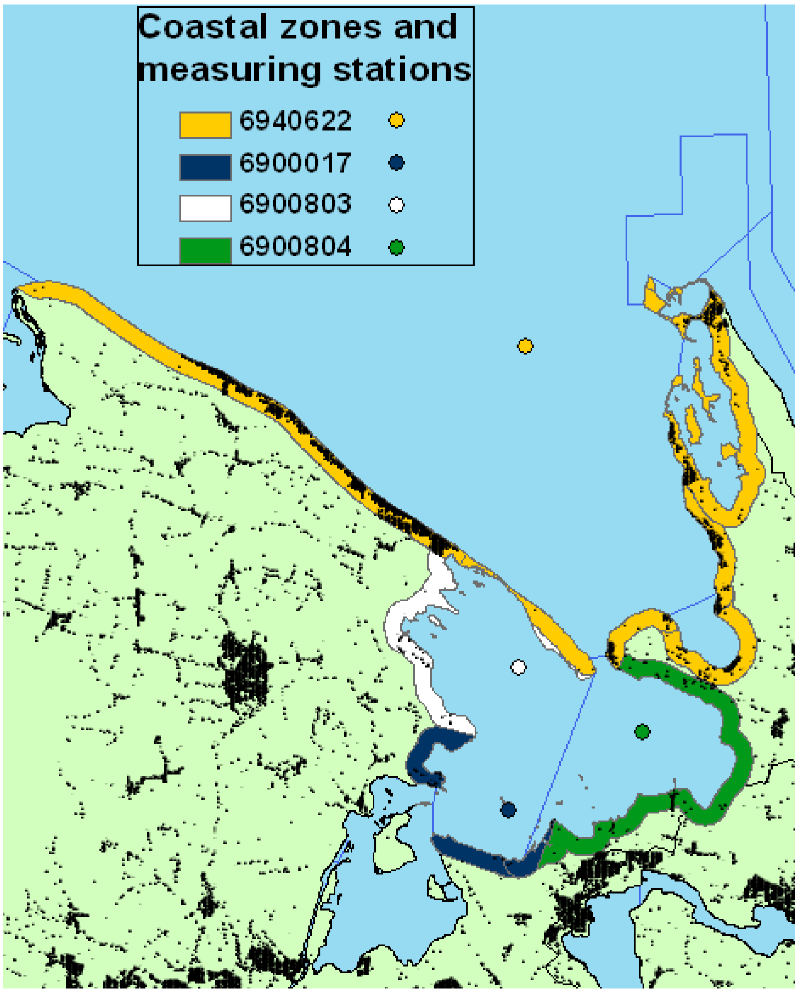

Figure 2: Map of water bodies in and around Odense Fjord indicating coastal zones and measuring stations.

GIS data from the Danish Buildings and Housing Register contains information on residential space in each building (BBR, 2005). The total residential area within each coastal zone in Figure 2 is seen in Table 2 below.

On a long term basis house prices can be assumed to reflect construction costs and we work from this assumption to simplify and to avoid factoring in bubbles in house prices (Madsen, 2008).

In Denmark the average construction cost of a “single-family house” including labour cost, material cost and fixed installations; excluding price of land and domestic appliances is 1063€/m2 in 2000-prices (Byggecentrum, 2007)(Danmarks Statistik, 2008). In Denmark the property value is approx 20% of the total sales price (SVUR, 2008) which is added on to the building price, giving a total cost of 1329€/m2. The price of the buildings is seen in Table 2. The affected value in €/m Secchi depth change in the four areas is found by applying the 3.3% change in property cost per m water clarity change.

The property value for the coastal zone of the catchment has been indexed with the alternative interest rate of capital and annualised over a 30 year period (cf. method of Møller et al. 1999).

Table 2: House price affected by change in water clarity, Odense catchment.

Coastal zone	Buildings, m2	Price of buildings (mio €, DK 2000)	Affected property value (€/m Secchi) (DK2000)	Annualised value (€/(m Secchi*y)) (DK2000)
6900017	2,343	3.1	103,485	7,518
6900804	10,519	14.0	464,599	33,753
6900803	4,740	6.3	209,355	15,209
6940622	213,115	283.2	9,412,783	683,828

2.3 Ouse catchment

The outlet of the Ouse catchment is into the Humber Estuary. GIS data on residential buildings for the Humber Estuary was not readily available. The GIS data from the Danish Buildings and Housing Register (BBR, 2005) was combined with the Corine Land Cover (CLC) dataset (EEA, 2007) to estimate average residential building densities for the two CLC codes 111 (Continuous urban fabric) and 112 (Discontinuous urban fabric), see Table 3.

Table 3: m2 of residential area affected, Ouse catchment

CLC surface area	m2 of CLC area affected	Average residential building density	m2 of residential building
Kingston upon Hull 111. Continuous urban fabric	837,395	0.461	386,207
Kingston upon Hull 112. Discontinuous urban fabric	3,718,589	0.098	364,258
Grimsby. 112. Discontinuous urban fabric	1,958,192	0.098	191,817
Total	6,514,176		942,281

The same building densities were then applied to a 500m coastal zone at the Humber estuary (Figure 3) for the CLC codes 111 and 112 for. The result is a total of 942,281m2 of residential area affected (Table 3).

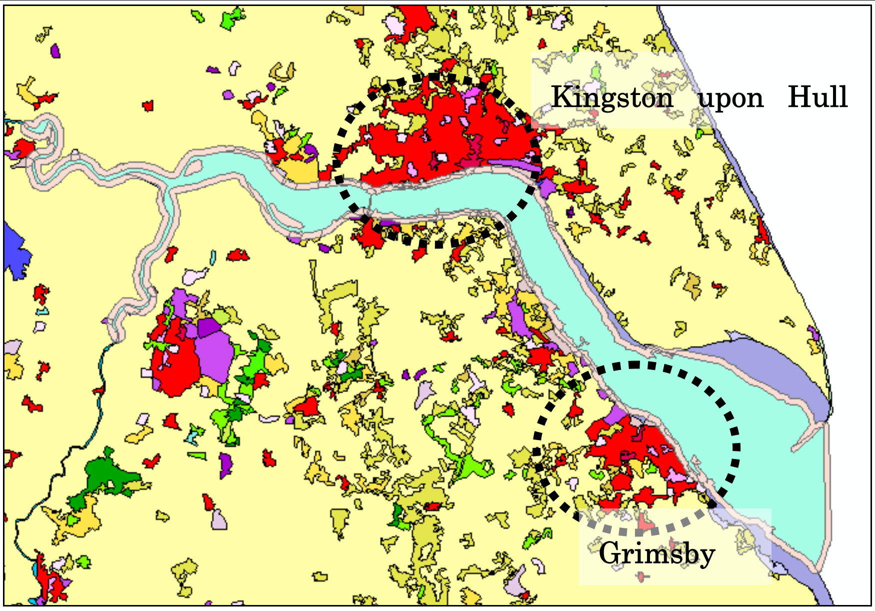

Figure 3: The Humber Estuary.

The residential area was distributed on 3 types of accommodation, single detached, semi-detached/row house, and apartments. Only the construction price per m2 of apartment block was readily available, the other two types were scaled.

Table 4: Sales price and constuction cost per m2 of different accommodation types in Norway and UK (Statistics Norway, 2007a and Office for National Statistics, 2005)

Accommodation type	Sales price Norway, (NOK, 2006)	Relative price	Consctruction cost UK (€, UK 2000)
Detached house	14,917	49.9%	1,292
Semi-detached or row house/terraced	18,607	62.3%	1,611
Apartment block	29,864	100.0%	2,586

The division on types of housing for the residential buildings in Kingston and Grimsby is seen in Table 5 (Office for National Statistics, 2005). There is 1% of mobile living units that are excluded from the analyses.

Table 5: Construction value of affected residential area, Kingston upon Hull and Grimsby.

Area	Accommodation type	Distribution (%)	Total area (m2)	Total value (mio. €, UK 2000)
Kingston	Single detached house	20%	150,093	194
	Semi-detached or row house/terraced	72%	540,335	871
	Apartment block	7%	52,533	136
	Total	99%	742,960	1,200
Grimsby	Single detached house	20%	38,363	50
	Semi-detached or row house/terraced	72%	138,108	222
	Apartment block	7%	13,427	35
	Total	99%	189,899	307
Total			932,859	1507

The total value of the affected residential area is thus estimated to 1,507 mio. € (UK, 2000). With a price change of 3.3% per meter change in Secchi depth the equivalent value change seen in Table 6 is 49.7 mio €/m Secchi depth (€, UK, 2000).

The property value for the coastal zone of the catchment has been indexed with the alternative interest rate of capital and annualised over a 30 year period (cf. method of Møller et al. 1999).

Table 6: House price affected by change in water clarity, Ouse catchment.

Coastal zone	Buildings, m2	Price of buildings (mio €, UK 2000)	Affected property value (mio €/m Secchi, UK2000)	Annualised value (€/(m Secchi*y), UK2000)
Kingston	742,960	1,200	39.6	2,877,350
Grimsby	189,899	307	10.1	735,443

2.4 Vansjø catchment

The valuation of property prices are performed using a distance of 500m from the water. The water areas included are the lakes in the lower part of the catchment and the river running through Moss city, see Figure 4 below.

Data on buildings in the counties covering the Vansjø catchment area was extracted from (Statens Kartverk, 2008). Approx. 13,000 buildings out of 227,000 were without XY location coordinates. The buildings were mostly additions to and modifications of existing buildings. These were updated according to a building number which they share with the existing building. Still 183 remains without XY data and are neglected as they present only 0.08% of the buildings.

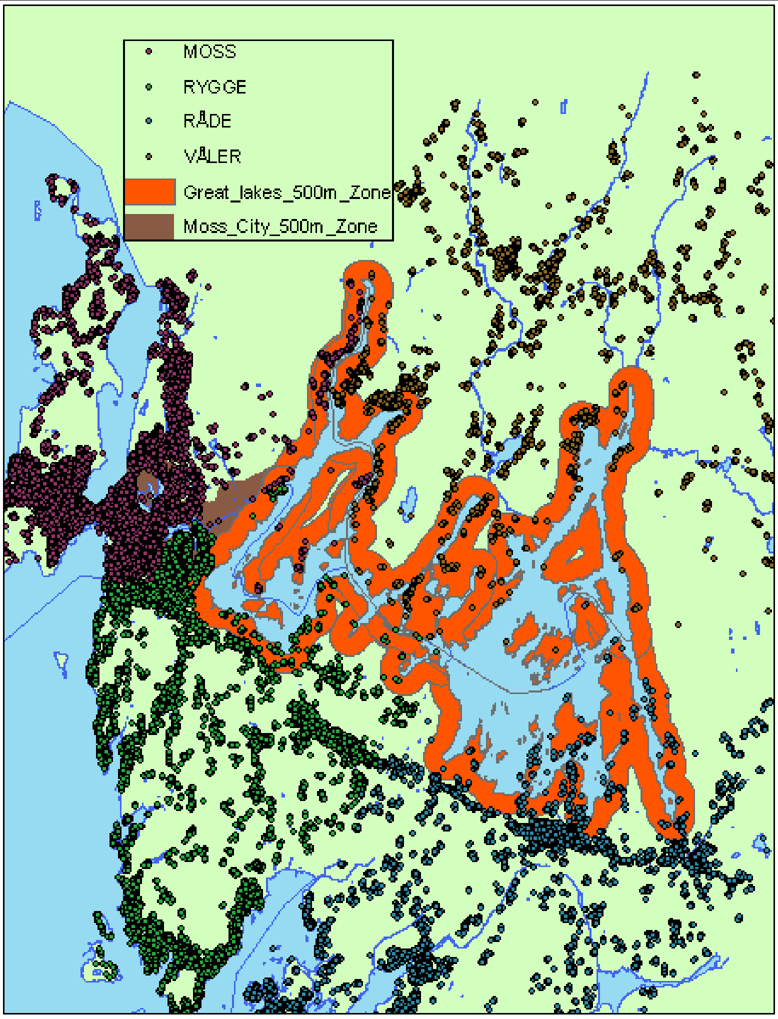

Figure 4: Buildings in the 4 municipalities and 500m zones around the lakes and the river in Moss city in lower Vansjø catchment

The residence houses affected within the 500m zone (single detached houses, row houses, and apartments) are seen in Table 7. The result is 2377 residence buildings with a total residence area of 465,381m2 and a value of 763.4 mio €. With an affected value of 3.3% per m Secchi depth the result is 25.2 mio €/m Secchi depth change. The unit values per m2 area are calculated from sales statistics from 2002-2007 (Statistics Norway, 2007) converted to 2000 prices in euro.

Table 7: Affected residential buildings in lower Vansjø catchment.

Municipality (Area)	Building type	No. of buildings	Residential area, m2	Unit price, €/m2 (€, 2000, NO)	Total price(mio €, 2000, NO)
Moss (Lake)	Single	17	2,012	1,539	3.1
Råde (Lake)	Single	28	3,599	1,327	4.8
Rygge (Lake)	Single	167	25,417	1,523	38.7
Våler (Lake)	Single	122	19,517	1,176	23.0
Moss (City)	Single	1,123	158,372	1,539	243.8
Moss (City)	Row house	287	57,805	1,432	82.8
Moss (City)	Appartment	85	88,690	2,114	187.5
Rygge (City)	Single	274	44,481	1,523	67.8
Rygge (City)	Row house	237	27,126	1,366	37.1
Rygge (City)	Appartment	37	38,362	1,955	75.0
Total		2,377	465,381		763.4

The holiday homes affected are seen in Table 8. The result is 441 holiday homes with a value of 30.4 mio €. With an affected value of 3.3% per m Secchi depth the result is 1.0 mio €/m Secchi depth change. The values per holiday home are calculated from sales statistics from 2002-2007 (Statistics Norway, 2007) converted to 2000 prices in euro.

Table 8: Affected holiday homes in lower Vansjø catchment.

Municipality (Area)	No. of buildings	Unit price, €/building (€, 2000, NO)	Total price(mio €, 2000, NO)
Moss (Lake)	72	97,654	7.0
Råde (Lake)	101	92,198	9.3
Rygge (Lake)	34	111,189	3.8
Våler (Lake)	207	35,286	7.3
Moss (City)	4	97,654	0.4
Rygge (City)	23	111,189	2.6
Total	441		30.4

The aggregated values are shown in Table 9 indexed with the alternative interest rate of capital and annualised over a 30 year period (cf. method of Møller et al. 1999).

Table 9: House price affected by change in water clarity, Vansjø catchment.

Coastal zone	Buildings, m2	Price of buildings (mio €, NO 2000)	Affected property value (mio €/m Secchi, NO2000)	Annualised value (€/(m Secchi*y), NO2000)
City area	50,545	97	3.20	232,496
Lake area	414,836	697	22.99	1,670,537

3 Valuation, impact-pathway 3 and 4

3.1 Mortality, Years Of Life Lost (YOLL)

In the current impact-pathway analysis a common EU-value per Year of Life Lost (YOLL) of 40,000 euro (2000-prices) has been agreed for the purpose of the EXIOPOL project. However, we also present results where country-specific YOLL's have been established (based on purchasing-power parities, cf. Navrud).

Table 10: Value per YOLL, country specific and common for EXIOPOL project.

Country	Conversion factor
Denmark	63,568
Czech Republic	23,466
Italy	49,518
Luxembourg	47,566
UK	58,543
Norway	67,178
EXIOPOL for EU/EEA	40,000

3.2 Morbidity, Cost of Illness (COI)

For valuation of the cancer incidences morbidity costs have been estimated for each country. Detailed cost-of-illness figures for morbidity costs reported in previous research have been used (Gundgaard et al., 2002; based on Cancer Registry, Cause-of-death Registry, the National Patient Registry, and the National Health Service Registry). Figures for the other EU-countries have been estimated by adjusting the Danish figures with purchasing-power parities.

According to the oncology department of the national hospital (Pedersen, 2008, personal communication) medicine being part of cancer treatment but taken outside hospitals is issued directly from the hospitals and hence the costs are included in the costs obtained from the National Health Service Registry.

The figures presented in (Gundgaard et al., 2002) can be used to assess the costs-of-illness related to specific cancer types.

The cancer treatment is most expensive the first year after diagnosis, and then declining the following years. Data is available only for the first year per specific cancer site, and the decline in cost the following years is available per average cancer incidence. These two data sets are combined to give an estimated treatment cost per person depending on the year after diagnosis (Figure 5). The figure also gives an indication of the reference public health system cost of an average person without cancer aged 55+ (based on Gundgaard et al., 2002) to be subtracted to give only the extra cost of the cancer incidence and not the total treatment cost.

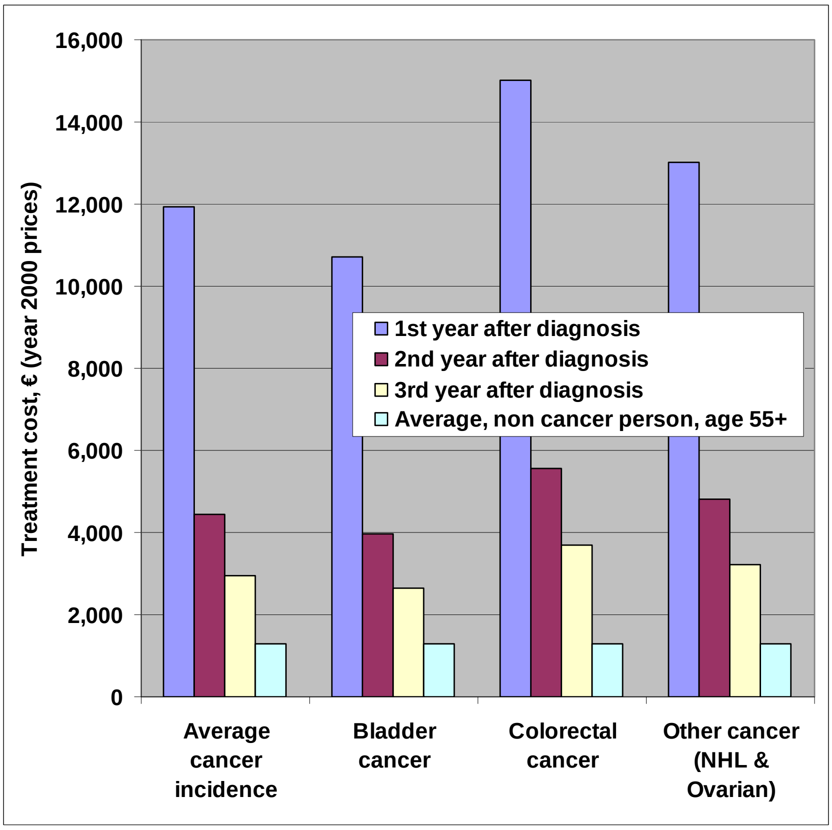

Figure 5: Treatment cost (euro, year 2000, DK prices) of cancer incidents per year after diagnosis and treatment cost of an average person aged 55+ without cancer.

The mortality rate of the specific cancer incidents have been included, to take account of the resulting reductions in morbidity costs (Gundgaard et al., 2002) A linear interpolation to the mid-year interval is used to represent the average fraction receiving treatment. The result is presented in Figure 6 below.

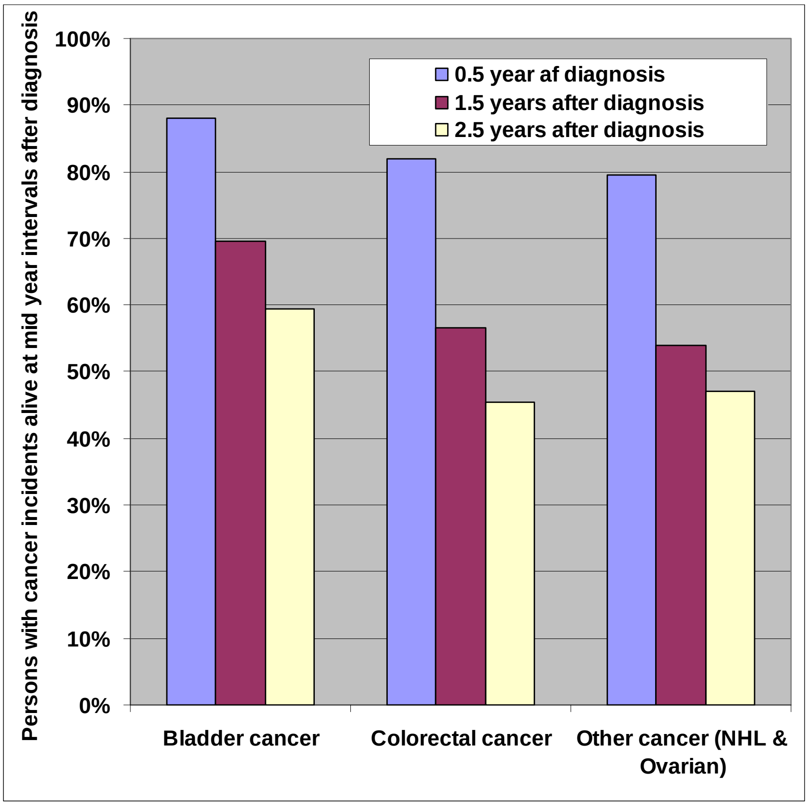

Figure 6: Survival rate per mid-year interval.

The average treatment cost of the cancer incidence is now calculated as the cost of cancer treatment subtracted the treatment cost of an average non cancer person (Figure 5) and multiplied with the fraction of persons alive at the mid-year intervals after diagnosis (Figure 6). The result is shown in Table 11 below in year 2000 prices and under Danish conditions.

Table 11: Average extra treatment cost per cancer incidence (euro, year 2000, Denmark)

Cancer site	Cost, (€, year 2000, Denmark)
Bladder cancer	10,949
Colorectal cancer	14,747
NHL (*)	12,098
Ovarian cancer(*)	12,098

(*) NHL and ovarian cancer not specified; “other cancer” used.

3.2.1 Loss of productivity and welfare

3.2.1.1 Days hospitalized and day-visits

The number of days hospitalized and the number of day-visits per cancer type are calculated based on the total number of bed-days and day-visits registered to that diagnose (Sundhedsstyrelsen, 2006) divided by the number of new cancer incidences per cancer site in 2004, see Table 12 (Sundhedsstyrelsen, 2008). The transfer between calendar years is assumed to even out, i.e. patients transferred from 2003 or before is assumed equal to patients transferred into 2005 or later. Some grouping or exclusions of diagnoses is necessary to align the two registries as indicated in the comment field. Days of hospitalization is multiplied with 5/7 to find the number of workdays in hospitalization assuming that hospitalization is also taking place in weekends. Day-visits are assumed only to take place on work-days and are assumed to cause a full day of absence from work.

Table 12: Days hospitalized and day visits, total and per cancer incidence in 2004 (Sundhedsstyrelsen 2006 and 2008).

Cancer site (ICD-10)	Incidenses 2004.	Hospitalization days		Day-visits		Comment
		Total	Work-days per incidence	Total	Work-days per incidence	
Bladder (C67)	2,114	29,842	10.1	12,950	6.1	All C64-C68 included for consistency
Colorectal (C18-21)	3,972	73,771	13.3	40,386	10.2	C21 left out for consistency
NHL (C82-85)	1,357	42,006	22.1	48,275	35.6	All C81-C90 included for consistency
Ovarian cancer (C56)	2,487	21,854	13.2	16,878	14.3	C54-56 incl for consistency

3.2.1.2 Days of recuperation

From the cancer cohort used in (Carlsen, 2008) data is extracted covering the value of sickness benefit as it appears on tax returns in the period 1981-2000, extracted from Statistics Denmark, see Table 13 below. People employed in the public sector are receiving payment during illness, and their tax return will hence show normal salary payment and they will not appear in these statistics. However, the days of absence from work for a cancer patient is assumed the same whether employed in the private or public sector.

Table 13: Annual sickness benefit subtracted background population sickness (1980 prices)

Sickness benefit average	Year of diagnosis	Year 1 follow-up	Year 2 follow-up
Bladder cancer, DKR	2,634	4,019	531
Colorectal cancer, DKR	4,522	7,893	2,980
NHL, DKR	11,084	17,884	8,795
Ovarian cancer	7,101	15,985	9,518

This value covers people alive in the period, and is adjusted via the mortality from Figure 6 to model an average cancer incidence.

Divided by the value of sickness benefit in 1980 of 1612 DKR/week and multiplied with 5 workdays per week this gives the workdays of recuperation in Table 14 below.

Table 14: Workdays of recuperation per average cancer incidence.

Year	Year 0.5	Year 1.5	Year 2.5	Total
Bladder cancer	7.2	8.7	1.0	16.8
Colorectal cancer	11.5	13.8	4.2	29.5
NHL	27.3	30.0	12.8	70.1
Ovarian cancer	17.5	26.8	13.9	58.2

In the period 1980-2000 the employer paid 2-13 weeks of salary in case of sickness before the sickness benefits from the municipality as indicated in the table below.

Table 15: Employer period of sickness payment (Espensen, 2008) .

Year	1973-83	1983-87	1987-88	1988-90	1990-2000
Employer payment period (weeks)	5	13	5	5/13 (*)	2

(*) for private and public employment respectively.

Hence, one or more (in case of recurrence) periods of 2-13 weeks of additional absence might be 'hiding' in the numbers in Table 14. Furthermore, people with less than the 2-13 weeks of absence from work will not show up in the figures. Including the day-visits as full days of absence from work is partly making up for this.

3.2.1.3 Total productivity and welfare loss

Table 16 below sums up the days of productivity loss for one cancer incidence on hospitalization, day-visits and recuperation from Table 12 and Table 14 above.

Table 16: Workdays lost per cancer incidence per cancer site.

	Hospitalized (days)	Day-visits (days)	Recuperation (days)	Total (days)
Bladder cancer	10.1	6.1	16.8	33.0
Colorrectal cancer	13.3	10.2	29.5	53.0
NHL	22.1	35.6	70.1	127.8
Ovarian cancer	13.2	14.3	58.2	85.6

The workdays lost are multiplied with an average daily salary assumed equal to the average primary income added a productivity loss of 20%. The 20% is an estimate of the productivity loss of replacing a sick employee (DA, 2002). A Danish value is calculated in Table 17.

Table 17: Productivity loss per day (Danmarks Statistik, 2002).

Year	Primary income	Days per year	Daily income	Prod.loss	Total (kr)	Euro exchange rate	Euro
2000	156,00	252	622	1.2	747	7.4	101

The welfare loss per day is assumed equal to the productivity loss and the cost based amount in Table 17 is multiplied with 2 to account for welfare loss with the result of 202€/day (DK, 2000). The average daily salary is converted to the other catchments via purchasing power parities with the result in Figure 7. The calculations are also performed with a common EXIOPOL-value of 295€/day.

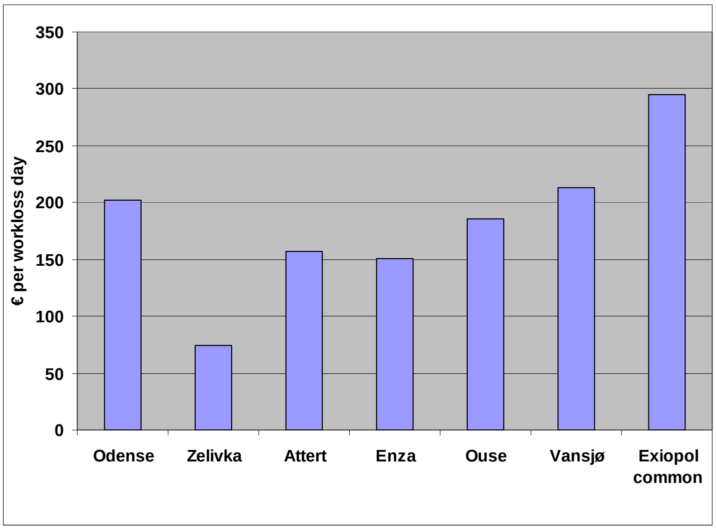

Figure 7: Value per workday lost, catchment specific and common for EXIOPOL project.

3.3 Odense catchment

The valuation of mortality is presented the standard Exiopol value of 40,000 €/YOLL and with the specific Danish value of 63,568 €/YOLL.

In Table 18 the extra treatment cost per cancer incidence is indicated .

Table 18: Average extra treatment cost per cancer incidence in Odense catchment

Cancer site	Danish cost, (€, 2000, DK)	Exiopol common (€, 2000)
Bladder cancer	10,949	8,403
Colorectal cancer	14,747	11,318
NHL	12,098	9,285
Ovarian cancer	12,098	9,285

The sum of days of hospitalization, day-visits and days of recuperation is in Table 19. The valuation is performed with a common Exiopol value of a workloss day of 295€/day and a catchment specific Danish value of 202€/day.

Table 19: Productivity and welfare loss per cancer incidence in Odense catchment.

	Total (days)	Danish (€, 2000, DK)	Exiopol common (€, 2000)
Bladder	33.0	6,672	9,747
Colorrectal	53.0	10,697	15,627
NHL	127.8	25,805	37,699
Ovarian cancer	85.6	17,284	25,252

3.4 Zelivka catchment

The valuation of mortality is carried out with the standard Exiopol value of 40,000 €/YOLL and with a specific Czech value of 23,466 €/YOLL.

The average extra treatment cost per cancer incidence (Table 18) has been converted to Czech conditions.

Table 20: Average extra treatment cost per cancer incidence in Zelivka catchment

Cancer site	Czech values, (€, 2000, CR)	Exiopol common (€, 2000)
Bladder cancer	4,042	8,403
Colorectal cancer	5,444	11,318
NHL	4,466	9,285
Ovarian cancer	4,466	9,285

The sum of days of hospitalization, day-visits and days of recuperation is in Table 19. The valuation is performed with a common Exiopol value of a workloss day of 295€/day and a catchment specific Czech value of 75€/day.

Table 21: Productivity and welfare loss per cancer incidence in Zelivka catchment.

Cancer site	Total (days)	Czech values (€, 2000, CR)	Exiopol common (€, 2000)
Bladder cancer	33.0	2,463	9,747
Colorectal cancer	53.0	3,949	15,627
NHL	127.8	9,526	37,699
Ovarian cancer	85.6	6,380	25,252

3.5 Attert catchment

The valuation of mortality is carried out with the standard Exiopol value of 45,000 €/YOLL and with a specific Luxembourg value of 49,518€/YOLL.

The average extra treatment cost per cancer incidence (Table 18) has been converted to Luxembourg conditions.

Table 22: Average extra treatment cost per cancer incidence in Attert catchment

Cancer site	Luxembourg, (€, 2000, LU)	Exiopol common (€, 2000)
Bladder cancer	8,529	8,403
Colorectal cancer	11,487	11,318
NHL	9,424	9,285
Ovarian cancer	9,424	9,285

The sum of days of hospitalization, day-visits and days of recuperation is in Table 192. The valuation is performed with a common Exiopol value of a workloss day of 295€/day and a catchment specific Luxembourg value of 157€/day.

Table 23: Productivity and welfare loss per cancer site in Attert catchment.

Cancer site	Total (days)	Luxembourg cost (€, 2000, LU)	Exiopol common (€, 2000)
Bladder cancer	33.0	5,197	9,747
Colorectal cancer	53.0	8,332	15,627
NHL	127.8	20,101	37,699
Ovarian cancer	85,6	13,464	25,252

3.6 Enza catchment

The valuation of mortality is carried out with the standard Exiopol value of 45,000 €/YOLL and with a specific Italian value of 47.566€/YOLL.

The average extra treatment cost per cancer incidence (Table 18) has been converted to Italian conditions.

Table 24: Average extra treatment cost per cancer incidence in Enza catchment

Cancer site	Italian cost, (€, 2000, IT)	Exiopol common (€, 2000)
Bladder cancer	8,193	8,403
Colorectal cancer	11,035	11,318
NHL	9,053	9,285
Ovarian cancer	9,053	9,285

The sum of days of hospitalization, day-visits and days of recuperation is in Table 194. The valuation is performed with a common Exiopol value of a workloss day of 295€/day and a catchment specific Italian value of 151€/day.

Table 25: Productivity and welfare loss per cancer site in Enza catchment.

Cancer site	Total (days)	Italian cost (€, 2000, IT)	Exiopol common (€, 2000)
Bladder cancer	33.0	4,992	9,747
Colorectal cancer	53.0	8,004	15,627
NHL	127.8	19,308	37,699
Ovarian cancer	85.6	12,933	25,252

3.7 Ouse catchment

The valuation of mortality is carried out with the standard Exiopol value of 45,000 €/YOLL and with a specific UK value of 58,543 €/YOLL.

The average extra treatment cost per cancer incidence (Table 18) has been converted to UK conditions.

Table 26: Average extra treatment cost per cancer incidence in Ouse catchment

Cancer site	UK cost, (€, 2000, UK)	Exiopol common (€, 2000)
Bladder cancer	10,083	8,403
Colorectal cancer	13,581	11,318
NHL	11,142	9,285
Ovarian cancer	11,142	9,285

The sum of days of hospitalization, day-visits and days of recuperation is in Table 194. The valuation is performed with a common Exiopol value of a workloss day of 295€/day and a catchment specific UK value of 186€/day.

Table 27: Productivity and welfare loss per cancer site in Ouse catchment.

Cancer site	Total (days)	UK cost (€, 2000, UK)	Exiopol common (€, 2000)
Bladder cancer	33.0	6,144	9,747
Colorectal cancer	53.0	9,851	15,627
NHL	127.8	23,764	37,699
Ovarian cancer	85.6	15,918	25,252

3.8 Vansjø catchment

The valuation of mortality is carried out with the standard Exiopol value of 45,000 €/YOLL and with a specific Norwegian value of 67,178€/YOLL.

The average extra treatment cost per cancer incidence (Table 18) has been converted to Norwegian conditions.

Table 28: Average extra treatment cost per cancer incidence in Vansjø catchment

Cancer site	Norwegian cost, (€, 2000, NO)	Exiopol common (€, 2000)
Bladder cancer	11,571	8,403
Colorectal cancer	15,584	11,318
NHL	12,786	9,285
Ovarian cancer	12,786	9,285

The sum of days of hospitalization, day-visits and days of recuperation is in Table 198. The valuation is performed with a common Exiopol value of a workloss day of 295€/day and a catchment specific Norwegian value of 213€/day.

Table 29: Productivity and welfare loss per cancer site in Vansjø catchment.

Cancer site	Total (days)	Norwegian cost, (€, 2000, NO)	Exiopol common (€, 2000)
Bladder cancer	33.0	7,051	9,747
Colorectal cancer	53.0	11,304	15,627
NHL	127.8	27,270	37,699
Ovarian cancer	85.6	18,266	25,252

4 Unit values per kg nutrient, impact-pathway 1 and 2

The derivation of monetary unit values per kg nutrient for impact-pathway 1 and 2 (Secchi depth) draw on emission scenarios and dose-response relations from deliverable DII2A-2 and effect-endpoint valuation from section 2. The detailed calculations including the values drawn from the previous deliverable are presented in Annex II. A more detailed explanation is provided below for the Odense catchment.

4.1 Odense catchment

The illustrative calculation below refers to scenario 1+2 (per kg N applied) and refers to Secchi depth change at measuring station 6900017, which is the reference station for coastal waters.

$$0.0331 \, {}^{\mu gN/l}\!/_{tN\,applied} \quad \bullet \quad 0.00291 \, {}^{m\,Secchi}\!/_{\mu gN/l} \quad \bullet \quad 7{,}518 \, {}^{€}\!/_{m\,Secchi \bullet y} = 0.7 \, {}^{€}\!/_{tN\,applied\,/\,y}$$

The unit values per kg N applied, per kg N emission and per kg N/ha for the three main scenarios are presented in Table 30 below, summing the unit values for the four measuring stations in the coastal outlet at Odense Fjord. For the complete data refer to Annex II.1.

Table 30: Unit values (€/(kg N*y)) for impact-pathway 1, Odense catchment.

	€ / (kg N applied*y) (DK2000)	€ / (kg N emission*y) (DK2000)	€ / (kg N/ha*y) (DK2000)
Scenario 1+2. Fertilizer use	0.0212	0.0722	720
Scenario 3+4: Arable land from forest	0.0242	0.0666	-
Scenario 5+6. Livestock population	0.0382	0.0724	1300

4.2 Ouse catchment

The unit values per kg N applied, per kg N emission and per kg N/ha for the three main scenarios are presented in Table 31 below, summing the unit values for the two locations of Kingston and Grimsby downstream of the Ouse catchment. For the complete data refer to Annex II.2

Table 31: Unit values (€/(kg N*y)) for impact-pathway 1, Ouse catchment.

	€ / (kg N applied*y) (UK2000)	€ / (kg N emission*y) (UK2000)	€ / (kg N/ha*y) (UK2000)
Scenario 1+2. Fertilizer use	0.0119	0.0410	1772
Scenario 3+4: Arable land from forest	0.0124	0.0378	-
Scenario 5+6. Livestock population	0.0155	0.0410	2309

4.3 Vansjø catchment

The unit values per kg P applied and per kg P/ha for the three main scenarios are presented in Table 32 belowin the lake area of Vansjø catchment. For the complete data refer to Annex II.3. Unit values per kg P emission can not be calculated based on the current modelling.

Table 32: Unit values (€/(kg N*y)) for impact-pathway 2, Vansjø catchment.

	€ / (kg N applied*y) (NO2000)	€ / (kg N emission*y) (NO2000)	€ / (kg N/ha*y) (NO2000)
Scenario 1+2. Fertilizer use	4.2	-	46,326
Scenario 3+4: Arable land from forest	4.2	-	-
Scenario 5+6. Livestock population	4.2	-	46,326

5 Unit values per kg nutrient, impact-pathway 3 and 4

The calculation of monetary unit values per kg nutrient for impact-pathway 3 and 4 (health costs) draw on emission scenarios and dose-response calculations from deliverable DII2A-2 and valuation calculations from chapter 3 in this deliverable. The total calculations including the values drawn from the previous deliverable are present in Annex III with a specific calculation performed in Table 52 in Annex III.2.

5.1 Odense catchment

The unit values per kg N applied, per kg N emission and per kg N/ha for the three main scenarios are presented in Table 33 below. For the complete data refer to Annex III.1.

Table 33: Unit values (€/(kgN*pers*y) for impact-pathway 4, Odense catchment.

	INCA-N model		N-LES model	
	Catchment specific	Exiopol common	Catchment specific	Exiopol common
	€, 2000, DK	€, 2000	€, 2000, DK	€, 2000
Values per kg N applied				
Scenario 1+2. Fertilizer use	3.07E-06	2.03E-06	2.26E-06	1.49E-06
Scenario 3+4: Arable land from forest	-	-		
Scenario 5+6. Livestock population	1.87E-06	1.23E-06	4.09E-06	2.69E-06
Values per kg N emission				
Scenario 1+2. Fertilizer use	-	-	7.76E-06	5.11E-06
Scenario 3+4: Arable land from forest	-	-	-	-
Scenario 5+6. Livestock population	-	-	7.76E-06	5.11E-06
Values per kg N/ha				
Scenario 1+2. Fertilizer use	1.02E-04	6.70E-05	7.69E-05	5.07E-05
Scenario 3+4: Arable land from forest	-	-	-	-
Scenario 5+6. Livestock population	6.17E-05	4.07E-05	1.39E-04	9.16E-05

5.2 Zelivka catchment

The unit values per kg N applied, per kg N emission and per kg N/ha for the three main scenarios are presented in Table 34 below. For the complete data refer to Annex III.2.

Table 34: Unit values (€/(kgN*pers*y) for impact-pathway 3, Zelivka catchment.

	Catchment specific	Exiopol common
	€, 2000, CR	€, 2000
Values per kg N applied		
Scenario 1+2. Fertilizer use	1.96E-05	3.48E-05
Scenario 3+4: Arable land from forest	3.88E-05	6.91E-05
Scenario 5+6. Livestock population	2.25E-05	4.00E-05
Values per kg N emission		
Scenario 1+2. Fertilizer use	1.46E-04	2.59E-04
Scenario 3+4: Arable land from forest	1.29E-04	2.30E-04
Scenario 5+6. Livestock population	1.46E-04	2.59E-04
Values per kg N/ha		
Scenario 1+2. Fertilizer use	1.19E-03	2.12E-03
Scenario 3+4: Arable land from forest	-	-
Scenario 5+6. Livestock population	1.37E-03	2.43E-03

5.3 Attert catchment

The unit values per kg N applied, per kg N emission and per kg N/ha for the three main scenarios are presented in Table 35 below. For the complete data refer to Annex III.3.

Table 35: Unit values (€/(kgN*pers*y) for impact-pathway 4, Attert catchment.

	Catchment specific	Exiopol common
	€, 2000, LU	€, 2000
Values per kg N applied		
Scenario 1+2. Fertilizer use	8.70E-07	7.58E-07
Scenario 3+4: Arable land from forest	-	-
Scenario 5+6. Livestock population	7.17E-07	6.24E-07
Values per kg N emission		
Scenario 1+2. Fertilizer use	2.48E-06	2.16E-06
Scenario 3+4: Arable land from forest	-	-
Scenario 5+6. Livestock population	2.48E-06	2.16E-06
Values per kg N/ha		
Scenario 1+2. Fertilizer use	1.36E-05	1.19E-05
Scenario 3+4: Arable land from forest	-	-
Scenario 5+6. Livestock population	1.12E-05	9.79E-06

5.4 Enza catchment

The unit values per kg N applied, per kg N emission and per kg N/ha for the three main scenarios are presented in Table 36 below. For the complete data refer to Annex III.4.

Table 36: Unit values (€/(kgN*pers*y) for impact-pathway 4, Enza catchment.

	Catchment specific	Exiopol common
	€, 2000, IT	€, 2000
Values per kg N applied		
Scenario 1+2. Fertilizer use	1.36E-05	1.22E-05
Scenario 3+4: Arable land from forest	-	-
Scenario 5+6. Livestock population	9.13E-06	8.19E-06
Values per kg N emission		
Scenario 1+2. Fertilizer use	3.64E-05	3.27E-05
Scenario 3+4: Arable land from forest	-	-
Scenario 5+6. Livestock population	3.64E-05	3.27E-05
Values per kg N/ha		
Scenario 1+2. Fertilizer use	4.90E-04	4.39E-04
Scenario 3+4: Arable land from forest	-	-
Scenario 5+6. Livestock population	3.28E-04	2.94E-04

5.5 Ouse catchment

The unit values per kg N applied, per kg N emission and per kg N/ha for the three main scenarios are presented in Table 37 below. For the complete data refer to Annex III.5.

Table 37: Unit values (€/(kgN*pers*y) for impact-pathway 3, Ouse catchment.

	Catchment specific	Exiopol common
	€, 2000, UK	€, 2000
Values per kg N applied		
Scenario 1+2. Fertilizer use	5.28E-06	3.81E-06
Scenario 3+4: Arable land from forest	5.52E-06	3.98E-06
Scenario 5+6. Livestock population	6.85E-06	4.94E-06
Values per kg N emission		
Scenario 1+2. Fertilizer use	1.82E-05	1.31E-05
Scenario 3+4: Arable land from forest	1.69E-05	1.22E-05
Scenario 5+6. Livestock population	1.81E-05	1.31E-05
Values per kg N/ha		
Scenario 1+2. Fertilizer use	1.04E-03	7.52E-04
Scenario 3+4: Arable land from forest	-	-
Scenario 5+6. Livestock population	1.35E-03	9.75E-04

5.6 Vansjø catchment

The unit values per kg N applied, per kg N emission and per kg N/ha for the three main scenarios are presented in Table 38 below. For the complete data refer to Annex III.6.

Table 38: Unit values (€/(kgN*pers*y) for impact-pathway 3, Vansjø catchment.

	Catchment specific	Exiopol common
	€, 2000, NO	€, 2000
Values per kg N applied		
Scenario 1+2. Fertilizer use	2.89E-05	1.81E-05
Scenario 3+4: Arable land from forest	5.14E-05	3.22E-05
Scenario 5+6. Livestock population	2.19E-05	1.37E-05
Values per kg N emission		
Scenario 1+2. Fertilizer use	6.56E-05	4.11E-05
Scenario 3+4: Arable land from forest	6.55E-05	4.10E-05
Scenario 5+6. Livestock population	6.56E-05	4.11E-05
Values per kg N/ha		
Scenario 1+2. Fertilizer use	2.96E-04	1.85E-04
Scenario 3+4: Arable land from forest	-	-
Scenario 5+6. Livestock population	2.25E-04	1.41E-04

6 Discussion

6.1 Unit values

The figures below summarize the monetary unit values for external costs of agricultural nutrient grouped by impact-pathway. The figures are divided in two with the unit values per kg applied and per kg N emission on the left part, and the unit values per kg N/ha on the right part.

The results are shown for the three main scenarios; changes in application of artificial fertilizer, changes in area of arable land, and change in livestock population.

6.1.1 Impact-pathway 1, Secchi depth (coastal water)

The unit values for impact-pathway 1 covering changes in Secchi depth and the related impact for property values are presented in Figure 8 below. The external costs for the two catchments are in the same order of magnitude with values of approx. 0.02-0.04€/(kg N applied*y), 0.04-0.07€/(kg N emission*y), and 700-2,300€ /(kg N/ha*y).

External costs per kg N emission are higher than per kg N applied for the two catchments. The amounts of applied nitrogen are higher than emitted values due to the intended plant uptake, leading to a higher unit value per kg N emission than per kg N applied, as it is the same response that is observed.

External costs per kg N applied when increasing livestock (Sce 5+6) are higher than when increasing fertilizer (Sce 1+2), equivalent to a higher nitrogen loss from manure than from artificial fertilizer. The pattern is stronger for Odense catchment than for Ouse. The change in arable land (Sce 3+4) encompasses change in both manure and artificial fertilizer application and is between the two other scenarios. Once lost to the root zone (per kg N emission), the further transport to the recipient is equal. The same pattern is seen per kg N/ha (right part of figure).

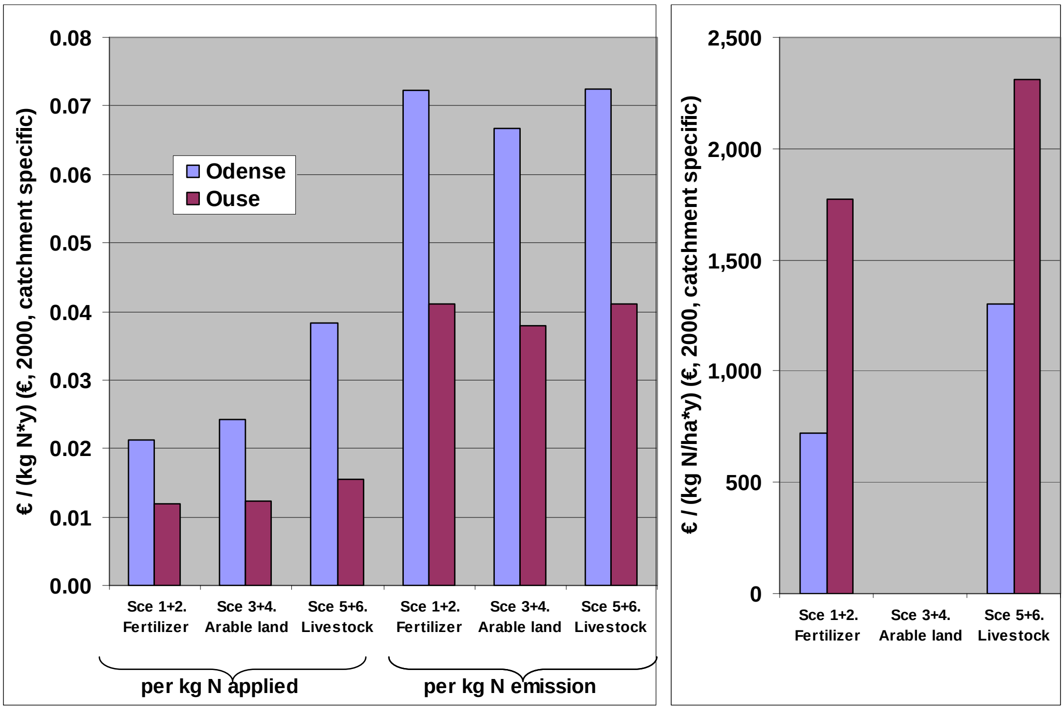

Figure 8: Unit values for I-P 1, catchment specific values

(Boyle et al., 1999) points out that it is easier and cheaper to protect a water body from a decrease in water clarity than it is to re-establish it; hence the loss of a reduction in clarity exceeds the gain from an equal improvement in clarity. The local conditions in the Odense and Ouse catchments for marine waters and Vansjø for freshwater are not examined well enough in this study to take this into account.

6.1.2 Impact-pathway 2, Secchi depth (freshwater lakes)

The unit values for phosphorus are not specified in the different scenarios describing changes in fertilizer application, arable land or livestock population. Furthermore, no modelling of emission are performed, only applied values. The result is 4.2€/(kg P applied*y) and 46,326€/(kg P/ha*y).

6.1.3 Impact-pathway 3, Nitrate-induced cancer (surface water for drinking)

The unit values for impact-pathway 3 covering use of surface water for drinking are seen in Figure 9 using catchment specific valuation, and in Figure 10 using EXIOPOL common valuation.

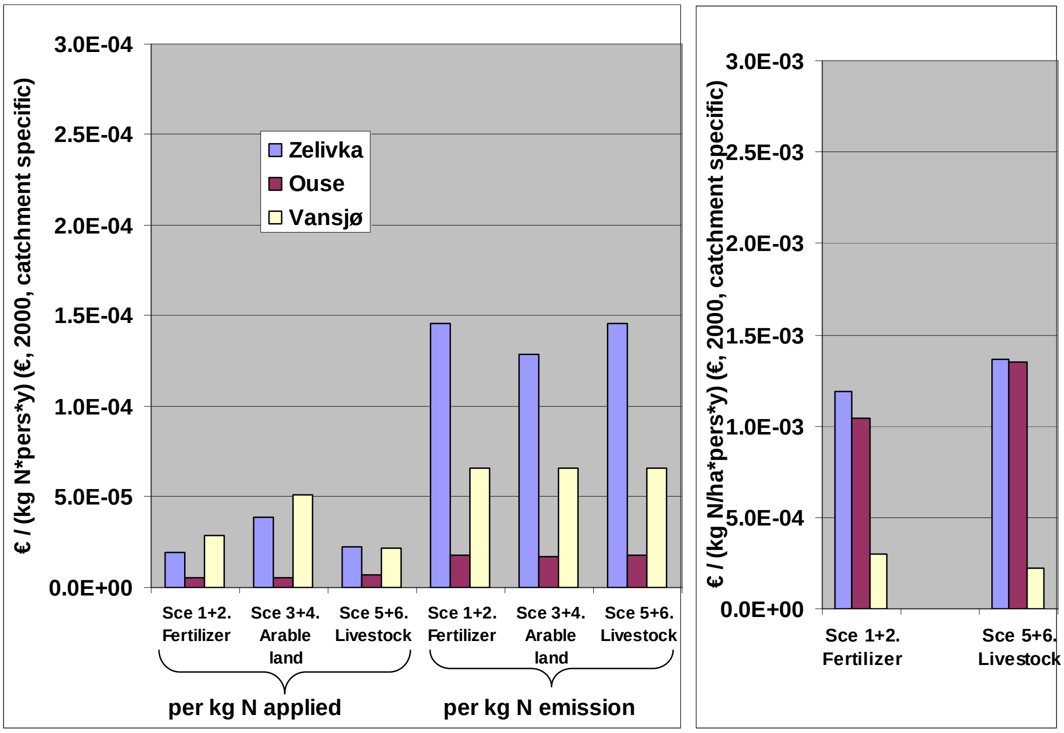

Figure 9: Unit values for I-P 3, catchment specific values

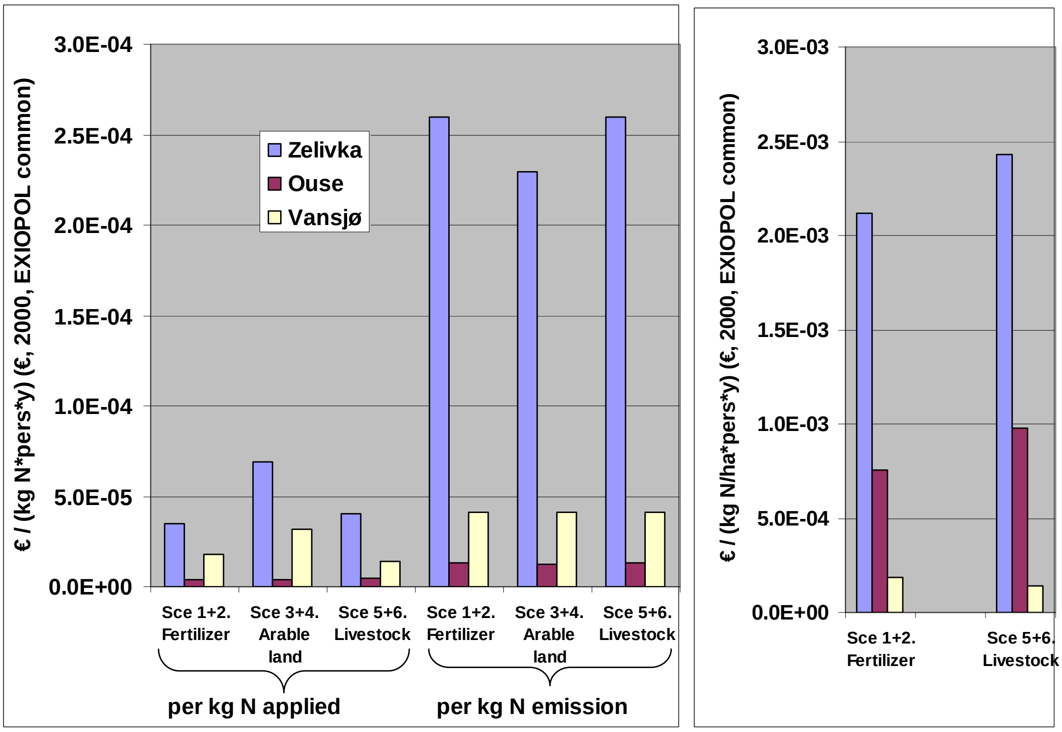

Figure 10: Unit values for I-P 3, EXIOPOL common values

Figure 10 shows the unit values using Exiopol common valuation for the three catchments of included in impact-pathway 3. The left part of the figure shows unit values per kg N applied and per kg N emission. The difference between the three catchments mainly reflects differences in the emission-dispersion relation. The dose-response relations are similar, and the valuations are identical using common Exiopol values. The right part of the figure is added the perspective of the total size of arable land in the catchment, Ouse catchment having the largest area and Vansjø having the smallest area of arable land.

Going from Figure 10 to Figure 9, the unit values from Zelivka catchment becomes smaller as catchment specific valuation is used. This is equivalent to that the purchasing power in the Czech Republic is lower than in Norway and UK.

6.1.4 Impact-pathway 4, Nitrate-induced cancer (groundwater)

The unit values for impact-pathway 4 covering use of groundwater for drinking are seen in Figure 11 using catchment specific values and in Figure 12 using EXIOPOL common value for value of year of life lost (YOLL) and workloss day.

(Hansen, 2006) models that for the Odense catchment 1% of a nitrate pulse released in the root zone would be left after 10 years; the rest denitrified or leached. This value is used for the Odense and Attert catchments in Figure 11 and Figure 12. The Enza catchment has sandy soil and here a reduction value due to denitrification of 10% is used (Refsgaard, 2009). Hence the results found for Enza catchment are higher than for Odense and Attert, reflecting the increased vulvnerability of groundwater under sandy soil compared to groundwater under claey soil.

For Odense catchment, calculations are performed using two different models; the simple N-LES model and the more sophisticated INCA-N model.

The INCA-N models the average nitrate concentration in the upper receiving groundwater, where as the N-LES version estimates average groundwater nitrate concentration 10 years ahead. The actual age of the groundwater in Odense city is approx. 30-40 years old; hence the INCA-N version could be said to be more precisely modelled but the N-LES closer to the actual age of the groundwater used for drinking.

For both models, the response used in this study can be considered an upper bound estimate. One estimate could be that from by the groundwater age of 30-40 years another 99% of the nitrate left at 10 years would dissapear.

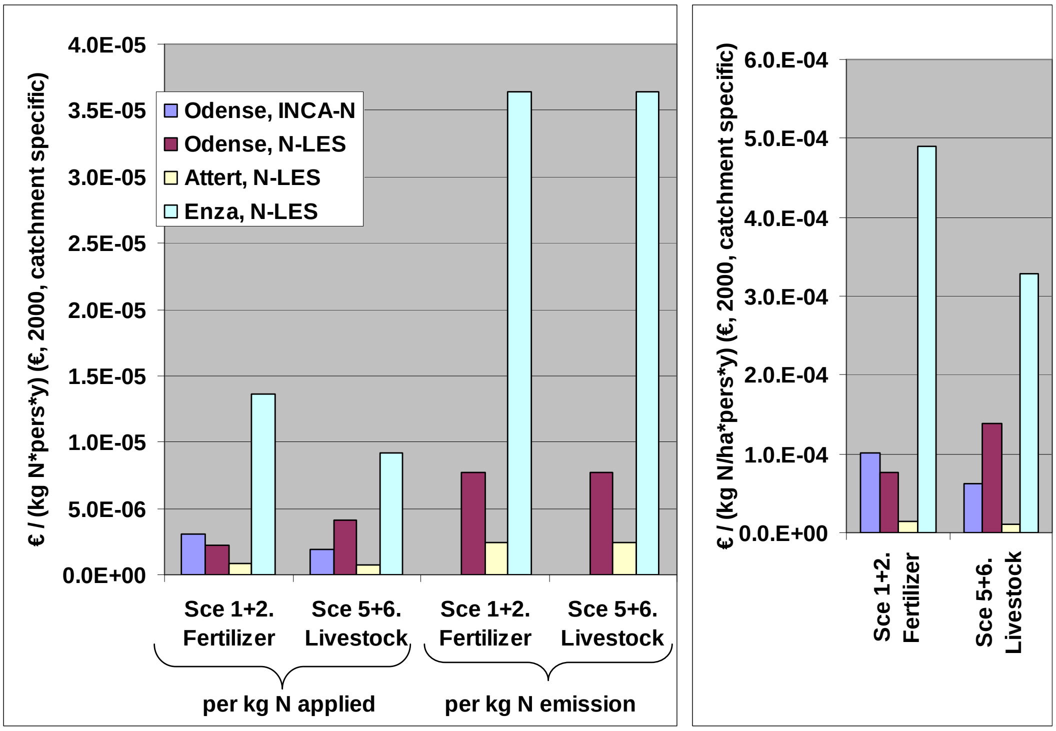

Figure 11: Unit values for I-P 4, catchment specific values

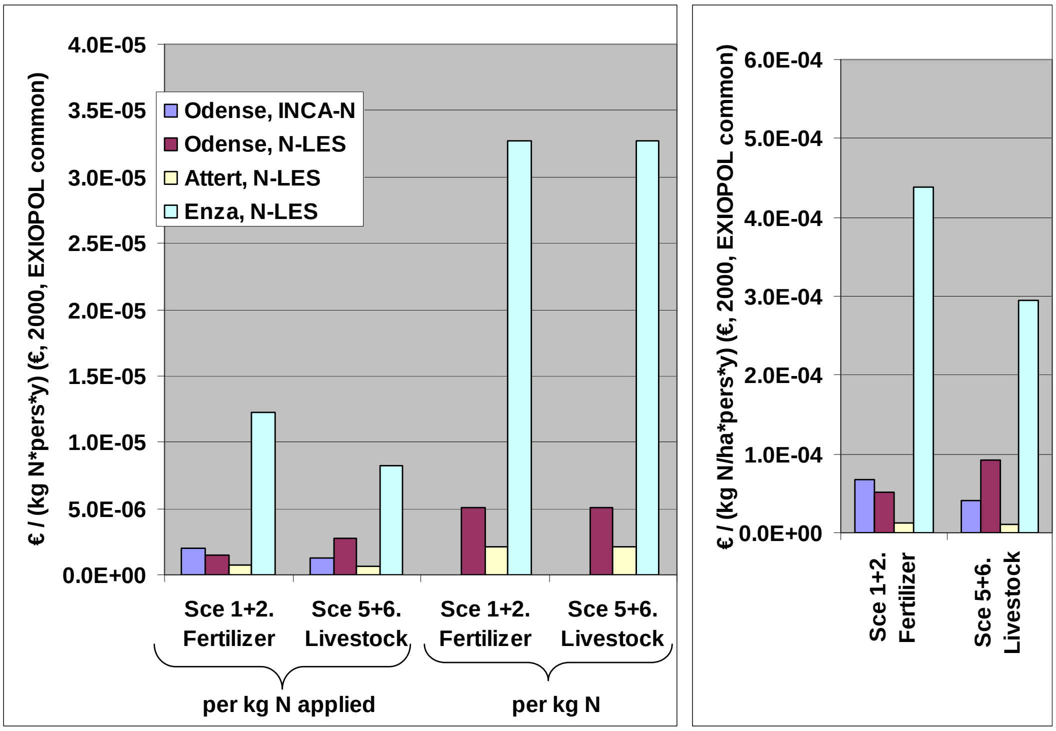

Figure 12: Unit values for I-P 4, EXIOPOL common values

Figure 11 and Figure 12 above show the concentration increase per kg of nitrogen and not the absolute concentrations. The absolute concentrations in Odense and Attert catchments are just below 1 mg/l NO3 and thus might be below the threshold value for which the cancer effects would occur. The calculations are still presented but keeping the threshold value in mind.

7 Conclusions

7.1. External costs and IO unit values

The impact-pathway approach was developed in the ExternE project to evaluate air pollution emissions. This study is seen as a pilot approach to using the impact-pathway methodology to evaluate emissions to water. The pilot status means that only a limited number of responses are evaluated, with the effect that the results do not reflect the total costs per kg nutrient.

Furthermore, the pilot approach means that a complete modelling of the impact-pathway has not been performed. Several transfers are made from literature to develop the methodology; estimating population from Corine Land Cover, transfering valuation of water clarity from US studies, and using a simple denitrification effect for groundwater nitrate.

In order to reach the same level of consistency in the methodology as on air pollution emissions, further development is necessary.

The external costs per kg nutrient applied will constitute the 'unit values' per kg nutrient to be used as a basis for the externality adders to the agricultural sectors in the EXIOPOL I-O tables.

7.2. WFD-disproportionality

In the context of the water framework directive (WFD) it has become important to consider whether costs are disproportionate to benefits. Demonstrating disproportionality is a precondition for obtaining exemptions from the WFD-requirements in individual catchments.

Although the quantification of nitrate's significance for cancer remains under discussion, we stipulate that the above figures probably represent an upper bound estimate for the effects that can be quantified on basis of the existing knowledge. We have opted for a precautionary approach in monetizing the possible costs for human health.

The impact on property prices of changes in Secchi-depth, on the other hand, represents an average of more location-specific circumstances, and could well be exceeded in some neighbourhoods and catchments. There are also valuation studies which link changes in Secchi-depth with frequency of tourist visits.

We stress the incompleteness of the present estimates in that a number of additional effect end-points could also be linked to nutrient reduction. As in EXIOPOL the agriculture workstream does not include impacts on biodiversity, we have not developed separate impact pathways to specify the well known effects of nutrients related to for instance fish stocks, bird life or vegetation. Once such additional effect end-points are added it would likely be possible to demonstrate higher external costs (and benefits), but the magnitude of these benefits remain for the present unknown.

In the present situation the figures presented here nevertheless represent the best available estimates for the external costs of nutrient application in the agricultural sector and allow for certain observations and conclusions.

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Annex I Contributors to the report

This report is the result of discussions between all partners in the EXIOPOL consortium. It has written by Morten Søes Hansen and Mikael Skou Andersen, National Environmental Research Institute, Aarhus University, Denmark.

Annex II Unit values for impact-pathway 1 and 2

Annex II.1 Odense catchment, impact-pathway 1

An example calculation from Table 39 on scenario 1+2 for measuring station 6900017:

$$0.0331 \, {}^{\mu gN/l}\!/_{tN\ applied} \bullet 0.00291 \, {}^{m\,Secchi}\!/_{\mu gN/l} \bullet 103{,}485 \, {}^{€}\!/_{m\,Secchi \bullet y} = 0.01 \, {}^{€}\!/_{kg\ N\ applied\ /\ y}$$

Table 39: Unit values per kg N applied, Odense catchment (€, 2000, DK).

Scenarios	Unit	Measuring station				Total
		6900017	6900804	6900803	6940622	
Dispersion						
Scenario 1+2. Fertilizer use	(µg N/l) / (t $N_{applied}$)	0.0331	0.0107	0.0144	0.0026	
Scenario 3+4: Arable land from forest		0.0378	0.0122	0.0164	0.0030	
Scenario 5+6. Livestock population		0.0598	0.0193	0.0260	0.0048	
Dose-response						
All scenarios	(m Secchi)/(µg N/l)	0.00291	0.00685	0.00685	0.00913	
Valuation						
All scenarios	€ / (m Secchi*y)	7,518	33,753	15,209	683,828	
Unit values						
Scenario 1+2. Fertilizer use	€ / (kg $N_{applied}$*y)	0.0007	0.0025	0.0015	0.0165	0.021
Scenario 3+4: Arable land from forest		0.0008	0.0028	0.0017	0.0188	0.024
Scenario 5+6. Livestock population		0.0013	0.0045	0.0027	0.0298	0.038

Table 40: Unit values per kg N emission, Odense catchment (€, 2000, DK).

Scenarios	Unit	Measuring station				Total
		6900017	6900804	6900803	6940622	
Dispersion						
Scenario 1+2. Fertilizer use	(µg N/l) / (t $N_{emission}$)	0.1129	0.0364	0.0490	0.0090	
Scenario 3+4: Arable land from forest		0.1042	0.0336	0.0453	0.0083	
Scenario 5+6. Livestock population		0.1132	0.0365	0.0492	0.0090	
Dose-response						
All scenarios	(m Secchi)/(µg N/l)	0.00291	0.00685	0.00685	0.00913	
Valuation						
All scenarios	€ / (m Secchi*y)	7,518	33,753	15,209	683,828	
Unit values						
Scenario 1+2. Fertilizer use	€ / (kg $N_{emission}$*y)	0.0025	0.0084	0.0051	0.0562	0.072
Scenario 3+4: Arable land from forest		0.0023	0.0078	0.0047	0.0519	0.067
Scenario 5+6. Livestock population		0.0025	0.0085	0.0051	0.0563	0.072

Table 41: Unit values per kg N/ha, Odense catchment (€, 2000, DK).

Scenarios	Unit	Measuring station				Total
		6900017	6900804	6900803	6940622	
Dispersion						
Scenario 1+2. Fertilizer use	(µg N/l) / (kg N/ha)	1.1264	0.3635	0.4891	0.0897	
Scenario 3+4: Arable land from forest		-	-	-	-	
Scenario 5+6. Livestock population		2.0338	0.6563	0.8832	0.1621	
Dose-response						
All scenarios	(m Secchi)/(µg N/l)	0.00291	0.00685	0.00685	0.00913	
Valuation						
All scenarios	€ / (m Secchi*y)	7,518	33,753	15,209	683,828	
Unit values						
Scenario 1+2. Fertilizer use	€ / (kg N/ha*y)	24.6	84.1	51.0	560.4	720
Scenario 3+4: Arable land from forest		-	-	-	-	-
Scenario 5+6. Livestock population		44.5	151.8	92.0	1011.9	1,300

Annex II.2 Ouse catchment, impact-pathway 1

Table 42: Unit values per kg N applied, Ouse catchment (€, 2000, UK).

Scenarios	Unit	Area		Total
		Kingston	Grimsby	
Dispersion				
Scenario 1+2. Fertilizer use	(µg N/l) / (t $N_{applied}$)	0.0164	0.0076	
Scenario 3+4: Arable land from forest		0.0171	0.0079	
Scenario 5+6. Livestock population		0.0214	0.0099	
Dose-response				
All scenarios	(m Secchi)/(µg N/l)	0.000170	0.000695	
Valuation				
All scenarios	€ / (m Secchi*y)	2,877,350	735,443	
Unit values				
Scenario 1+2. Fertilizer use	€ / (kg $N_{applied}$*y)	0.0080	0.0039	0.0119
Scenario 3+4: Arable land from forest		0.0083	0.0040	0.0124
Scenario 5+6. Livestock population		0.0105	0.0050	0.0155

Table 43: Unit values per kg N emission, Ouse catchment (€, 2000, UK).

Scenarios	Unit	Area		Total
		Kingston	Grimsby	
Dispersion				
Scenario 1+2. Fertilizer use	(µg N/l) / (t $N_{emission}$)	0.0565	0.0261	
Scenario 3+4: Arable land from forest		0.0522	0.0241	
Scenario 5+6. Livestock population		0.0566	0.0261	
Dose-response				
All scenarios	(m Secchi)/(µg N/l)	0.00017	0.00070	
Valuation				
All scenarios	€ / (m Secchi*y)	2,877,350	735,443	
Unit values				
Scenario 1+2. Fertilizer use	€ / (kg $N_{emission}$*y)	0.0277	0.0133	0.0410
Scenario 3+4: Arable land from forest		0.0255	0.0123	0.0378
Scenario 5+6. Livestock population		0.0277	0.0133	0.0410

Table 44: Unit values per kg N/ha, Ouse catchment (€, 2000, UK).

Scenarios	Unit	Area		Total
		Kingston	Grimsby	
Dispersion				
Scenario 1+2. Fertilizer use	(µg N/l) / (kg N/ha)	3.2406	1.4957	
Scenario 3+4: Arable land from forest		-	-	
Scenario 5+6. Livestock population		4.2226	1.9489	
Dose-response				
All scenarios	(m Secchi)/(µg N/l)	0.00017	0.00017	
Valuation				
All scenarios	€ / (m Secchi*y)	2,877,350	735,443	
Unit values				
Scenario 1+2. Fertilizer use	€ / (kg N/ha*y)	1,585	187	1,772
Scenario 3+4: Arable land from forest		-	-	-
Scenario 5+6. Livestock population		2,065	244	2,309

Annex II.3 Vansjø catchment, impact-pathway 2

Table 45: Unit values per kg P applied, Vansjø catchment (€, 2000, NO).

Scenarios	Unit	Value
Dispersion		
Scenario 1+2. Fertilizer use	(µg P/l) / (t $P_{applied}$)	0.131
Scenario 3+4: Arable land from forest		0.131
Scenario 5+6. Livestock population		0.131
Dose-response		
All scenarios	(m Secchi)/(µg P/l)	0.0168
Valuation		
All scenarios	€ / (m Secchi*y)	1,903,034
Unit values		
Scenario 1+2. Fertilizer use	€ / (kg $P_{applied}$*y)	4.19
Scenario 3+4: Arable land from forest		4.19
Scenario 5+6. Livestock population		4.19

Table 46: Unit values per kg P/ha, Vansjø catchment (€, 2000, NO).

Scenarios	Unit	Value
Dispersion		
Scenario 1+2. Fertilizer use	(µg P/l) / (kg P/ha)	1.4485
Scenario 3+4: Arable land from forest		-
Scenario 5+6. Livestock population		1.4485
Dose-response		
All scenarios	(m Secchi)/(µg P/l)	0.01681
Valuation		
All scenarios	€ / (m Secchi*y)	1,903,034
Unit values		
Scenario 1+2. Fertilizer use	€ / (kg P/ha*y)	46,326
Scenario 3+4: Arable land from forest		-
Scenario 5+6. Livestock population		46,326

Annex III Unit values for impact-pathway 3 and 4

Annex III.1 Odense catchment, impact-pathway 4

Table 47: Unit values per kg N applied, INCA-N model, Odense catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		0.000177		0.000177	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.000107		0.000107	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.44E-04	3.68E-05	1.44E-04	3.68E-05
	Colorectal	6.14E-05	1.02E-05	6.14E-05	1.02E-05
	NHL	2.08E-05	4.10E-06	2.08E-05	4.10E-06
	Ovarian	2.96E-05	3.53E-06	2.96E-05	3.53E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	63,568	17,621	40,000	18,150
	Colorectal	63,568	25,443	40,000	26,945
	NHL	63,568	37,903	40,000	46,984
	Ovarian	63,568	29,383	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, DK / (kg N appl.*pers*y)		€, 2000 / (kg N appl.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	1.61E-06	1.15E-07	1.01E-06	1.18E-07
	Colorectal	6.89E-07	4.59E-08	4.34E-07	4.87E-08
	NHL	2.33E-07	2.74E-08	1.47E-07	3.40E-08
	Ovarian	3.33E-07	1.83E-08	2.09E-07	2.16E-08
	Total	3.07E-06		2.03E-06	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	9.79E-07	6.96E-08	6.16E-07	7.17E-08
	Colorectal	4.19E-07	2.79E-08	2.63E-07	2.96E-08
	NHL	1.42E-07	1.67E-08	8.90E-08	2.07E-08
	Ovarian	2.02E-07	1.11E-08	1.27E-07	1.31E-08
	Total	1.87E-06		1.23E-06	

The INCA-N model does not allow for calculation of values per kg N emission with the current setup.

Table 48: Unit values per kg N/ha, INCA-N model, Odense catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / kgN/ha		mg/l NO3 / kgN/ha	
Scenario 1+2. Fertilizer use		0.00584		0.00584	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.00355		0.00355	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
All scenarios	Bladder	1.44E-04	3.68E-05	1.44E-04	3.68E-05
	Colorectal	6.14E-05	1.02E-05	6.14E-05	1.02E-05
	NHL	2.08E-05	4.10E-06	2.08E-05	4.10E-06
	Ovarian	2.96E-05	3.53E-06	2.96E-05	3.53E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
All scenarios	Bladder	63,568	17,621	40,000	18,150
	Colorectal	63,568	25,443	40,000	26,945
	NHL	63,568	37,903	40,000	46,984
	Ovarian	63,568	29,383	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, DK / (kg N/ha*pers*y)		€, 2000 / (kg N/ha*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	5.33E-05	3.79E-06	3.36E-05	3.90E-06
	Colorectal	2.28E-05	1.52E-06	1.43E-05	1.61E-06
	NHL	7.70E-06	9.08E-07	4.85E-06	1.13E-06
	Ovarian	1.10E-05	6.07E-07	6.93E-06	7.13E-07
	Total	**1.02E-04**		**6.70E-05**	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	3.24E-05	2.30E-06	2.04E-05	2.37E-06
	Colorectal	1.38E-05	9.23E-07	8.71E-06	9.78E-07
	NHL	4.68E-06	5.51E-07	2.94E-06	6.84E-07
	Ovarian	6.69E-06	3.68E-07	4.21E-06	4.33E-07
	Total	**6.17E-05**		**4.07E-05**	

Table 49: Unit values per kg N applied, N-LES model, Odense catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		0.000130		0.000130	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.000235		0.000235	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.44E-04	3.68E-05	1.44E-04	3.68E-05
	Colorectal	6.14E-05	1.02E-05	6.14E-05	1.02E-05
	NHL	2.08E-05	4.10E-06	2.08E-05	4.10E-06
	Ovarian	2.96E-05	3.53E-06	2.96E-05	3.53E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	63,568	17,621	40,000	18,150
	Colorectal	63,568	25,443	40,000	26,945
	NHL	63,568	37,903	40,000	46,984
	Ovarian	63,568	29,383	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, DK / (kg N appl.*pers*y)		€, 2000 / (kg N appl.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	1.19E-06	8.42E-08	7.46E-07	8.68E-08
	Colorectal	5.07E-07	3.38E-08	3.19E-07	3.58E-08
	NHL	1.71E-07	2.02E-08	1.08E-07	2.50E-08
	Ovarian	2.45E-07	1.35E-08	1.54E-07	1.59E-08
	Total	**2.26E-06**		**1.49E-06**	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	2.14E-06	1.52E-07	1.35E-06	1.57E-07
	Colorectal	9.16E-07	6.11E-08	5.76E-07	6.47E-08
	NHL	3.10E-07	3.65E-08	1.95E-07	4.52E-08
	Ovarian	4.43E-07	2.44E-08	2.79E-07	2.87E-08
	Total	**4.09E-06**		**2.69E-06**	

Table 50: Unit values per kg N emission, N-LES model, Odense catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		0.000446		0.000446	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.000446		0.000446	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.44E-04	3.68E-05	1.44E-04	3.68E-05
	Colorectal	6.14E-05	1.02E-05	6.14E-05	1.02E-05
	NHL	2.08E-05	4.10E-06	2.08E-05	4.10E-06
	Ovarian	2.96E-05	3.53E-06	2.96E-05	3.53E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	63,568	17,621	40,000	18,150
	Colorectal	63,568	25,443	40,000	26,945
	NHL	63,568	37,903	40,000	46,984
	Ovarian	63,568	29,383	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, DK / (kg N emis.*pers*y)		€, 2000 / (kg N emis.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	4.07E-06	2.89E-07	2.56E-06	2.98E-07
	Colorectal	1.74E-06	1.16E-07	1.09E-06	1.23E-07
	NHL	5.88E-07	6.93E-08	3.70E-07	8.59E-08
	Ovarian	8.40E-07	4.63E-08	5.29E-07	5.44E-08
	Total	7.76E-06		5.11E-06	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	4.07E-06	2.89E-07	2.56E-06	2.98E-07
	Colorectal	1.74E-06	1.16E-07	1.09E-06	1.23E-07
	NHL	5.88E-07	6.93E-08	3.70E-07	8.59E-08
	Ovarian	8.40E-07	4.63E-08	5.29E-07	5.44E-08
	Total	7.76E-06		5.11E-06	

Table 51: Unit values per kg N/ha, N-LES model, Odense catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / kgN/ha		mg/l NO3 / kgN/ha	
Scenario 1+2. Fertilizer use		0.00442		0.00442	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.00798		0.00798	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.44E-04	3.68E-05	1.44E-04	3.68E-05
	Colorectal	6.14E-05	1.02E-05	6.14E-05	1.02E-05
	NHL	2.08E-05	4.10E-06	2.08E-05	4.10E-06
	Ovarian	2.96E-05	3.53E-06	2.96E-05	3.53E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	63,568	17,621	40,000	18,150
	Colorectal	63,568	25,443	40,000	26,945
	NHL	63,568	37,903	40,000	46,984
	Ovarian	63,568	29,383	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, DK / (kg N/ha*pers*y)		€, 2000 / (kg N/ha*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	4.03E-05	2.86E-06	2.54E-05	2.95E-06
	Colorectal	1.72E-05	1.15E-06	1.08E-05	1.22E-06
	NHL	5.83E-06	6.86E-07	3.67E-06	8.51E-07
	Ovarian	8.32E-06	4.59E-07	5.24E-06	5.39E-07
	Total	**7.69E-05**		**5.07E-05**	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	7.29E-05	5.18E-06	4.59E-05	5.33E-06
	Colorectal	3.11E-05	2.08E-06	1.96E-05	2.20E-06
	NHL	1.05E-05	1.24E-06	6.63E-06	1.54E-06
	Ovarian	1.50E-05	8.29E-07	9.47E-06	9.75E-07
	Total	**1.39E-04**		**9.16E-05**	

Annex III.2 Zelivka catchment, impact-pathway 3

Example calculations for cells with (*) in Table 52.

$$0.00346\, {}^{mg/l\,NO_3}\!/_{tN\,applied} \bullet 1.22\cdot 10^{-4}\, {}^{YOLL}\!/_{pers \bullet mg/l\,NO_3 \bullet y} \bullet 23{,}466\, {}^{€}\!/_{YOLL} = 9.94\cdot 10^{-6}\, {}^{€}\!/_{kg\,N\,applied \bullet pers \bullet y}$$

The eight cells labelled (#) are then added to give the total of 1.96E-05€/kg N applied.

Table 52: Unit values per kg N applied, Zelivka catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		(*) 0.00346		0.00346	
Scenario 3+4: Arable land from forest		0.00687		0.00687	
Scenario 5+6. Livestock population		0.00398		0.00398	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	(*) 1.22E-04	2.58E-05	1.22E-04	2.58E-05
	Colorectal	7.00E-05	1.13E-05	7.00E-05	1.13E-05
	NHL	1.08E-05	2.29E-06	1.08E-05	2.29E-06
	Ovarian	2.29E-05	4.14E-06	2.29E-05	4.14E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	(*) 23,466	6,505	40,000	18,150
	Colorectal	23,466	9,392	40,000	26,945
	NHL	23,466	13,992	40,000	46,984
	Ovarian	23,466	10,847	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, CR / (kg N appl.*pers*y)		€, 2000 / (kg N appl.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	(*)(#) 9.94E-06	(#) 5.81E-07	1.69E-05	1.62E-06
	Colorectal	(#) 5.69E-06	(#) 3.67E-07	9.69E-06	1.05E-06
	NHL	(#) 8.77E-07	(#) 1.11E-07	1.49E-06	3.73E-07
	Ovarian	(#) 1.86E-06	(#) 1.55E-07	3.18E-06	4.95E-07
	Total	1.96E-05		3.48E-05	
Scenario 3+4. Arable land from forest	Bladder	1.97E-05	1.15E-06	3.36E-05	3.22E-06
	Colorectal	1.13E-05	7.27E-07	1.92E-05	2.09E-06
	NHL	1.74E-06	2.20E-07	2.96E-06	7.40E-07
	Ovarian	3.70E-06	3.08E-07	6.30E-06	9.82E-07
	Total	3.88E-05		6.91E-05	
Scenario 5+6. Livestock population	Bladder	1.14E-05	6.67E-07	1.94E-05	1.86E-06
	Colorectal	6.53E-06	4.21E-07	1.11E-05	1.21E-06
	NHL	1.01E-06	1.28E-07	1.72E-06	4.28E-07
	Ovarian	2.14E-06	1.79E-07	3.65E-06	5.68E-07
	Total	2.25E-05		4.00E-05	

Table 53: Unit values per kg N emission, Zelivka catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		0.0258		0.0258	
Scenario 3+4: Arable land from forest		0.0228		0.0228	
Scenario 5+6. Livestock population		0.0258		0.0258	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.22E-04	2.58E-05	1.22E-04	2.58E-05
	Colorectal	7.00E-05	1.13E-05	7.00E-05	1.13E-05
	NHL	1.08E-05	2.29E-06	1.08E-05	2.29E-06
	Ovarian	2.29E-05	4.14E-06	2.29E-05	4.14E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	23,466	6,505	40,000	18,150
	Colorectal	23,466	9,392	40,000	26,945
	NHL	23,466	13,992	40,000	46,984
	Ovarian	23,466	10,847	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, CR / (kg N emis.*pers*y)		€, 2000 / (kg N emis.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	7.40E-05	4.33E-06	1.26E-04	1.21E-05
	Colorectal	4.23E-05	2.73E-06	7.22E-05	7.83E-06
	NHL	6.53E-06	8.27E-07	1.11E-05	2.78E-06
	Ovarian	1.39E-05	1.16E-06	2.37E-05	3.69E-06
	Total	1.46E-04		2.59E-04	
Scenario 3+4. Arable land from forest	Bladder	6.55E-05	3.83E-06	1.12E-04	1.07E-05
	Colorectal	3.75E-05	2.42E-06	6.39E-05	6.93E-06
	NHL	5.78E-06	7.32E-07	9.85E-06	2.46E-06
	Ovarian	1.23E-05	1.02E-06	2.09E-05	3.26E-06
	Total	1.29E-04		2.30E-04	
Scenario 5+6. Livestock population	Bladder	7.40E-05	4.33E-06	1.26E-04	1.21E-05
	Colorectal	4.23E-05	2.73E-06	7.22E-05	7.83E-06
	NHL	6.53E-06	8.27E-07	1.11E-05	2.78E-06
	Ovarian	1.39E-05	1.16E-06	2.37E-05	3.69E-06
	Total	1.46E-04		2.59E-04	

Table 54: Unit values per kg N/ha, Zelivka catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / kgN/ha		mg/l NO3 / kgN/ha	
Scenario 1+2. Fertilizer use		0.210		0.210	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.242		0.242	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.22E-04	2.58E-05	1.22E-04	2.58E-05
	Colorectal	7.00E-05	1.13E-05	7.00E-05	1.13E-05
	NHL	1.08E-05	2.29E-06	1.08E-05	2.29E-06
	Ovarian	2.29E-05	4.14E-06	2.29E-05	4.14E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	23,466	6,505	40,000	18,150
	Colorectal	23,466	9,392	40,000	26,945
	NHL	23,466	13,992	40,000	46,984
	Ovarian	23,466	10,847	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, CR / (kg N/ha*pers*y)		€, 2000 / (kg N/ha*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	6.04E-04	3.53E-05	1.03E-03	9.85E-05
	Colorectal	3.45E-04	2.23E-05	5.89E-04	6.39E-05
	NHL	5.33E-05	6.75E-06	9.08E-05	2.27E-05
	Ovarian	1.13E-04	9.45E-06	1.93E-04	3.01E-05
	Total	**1.19E-03**		**2.12E-03**	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	6.93E-04	4.05E-05	1.18E-03	1.13E-04
	Colorectal	3.97E-04	2.56E-05	6.76E-04	7.34E-05
	NHL	6.12E-05	7.75E-06	1.04E-04	2.60E-05
	Ovarian	1.30E-04	1.08E-05	2.22E-04	3.45E-05
	Total	**1.37E-03**		**2.43E-03**	

Annex III.3 Attert catchment, impact-pathway 4

Table 55: Unit values per kg N applied, Attert catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		0.000190		0.000190	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.000157		0.000157	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	2.56E-05	9.98E-06	2.56E-05	9.98E-06
	Colorectal	3.13E-05	8.64E-06	3.13E-05	8.64E-06
	NHL	1.44E-05	3.77E-06	1.44E-05	3.77E-06
	Ovarian	1.17E-05	2.16E-06	1.17E-05	2.16E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	49,518	13,726	40,000	18,150
	Colorectal	49,518	19,819	40,000	26,945
	NHL	49,518	29,525	40,000	46,984
	Ovarian	49,518	22,888	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, Lux / (kg N appl.*pers*y)		€, 2000 / (kg N appl.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	2.41E-07	2.60E-08	1.95E-07	3.44E-08
	Colorectal	2.94E-07	3.25E-08	2.38E-07	4.42E-08
	NHL	1.35E-07	2.11E-08	1.09E-07	3.36E-08
	Ovarian	1.10E-07	9.41E-09	8.92E-08	1.42E-08
	Total	8.70E-07		7.58E-07	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	1.99E-07	2.15E-08	1.61E-07	2.84E-08
	Colorectal	2.42E-07	2.68E-08	1.96E-07	3.65E-08
	NHL	1.11E-07	1.74E-08	9.00E-08	2.77E-08
	Ovarian	9.10E-08	7.75E-09	7.35E-08	1.17E-08
	Total	7.17E-07		6.24E-07	

Table 56: Unit values per kg N emission, Attert catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		0.000542		0.000542	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.000542		0.000542	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	2.56E-05	9.98E-06	2.56E-05	9.98E-06
	Colorectal	3.13E-05	8.64E-06	3.13E-05	8.64E-06
	NHL	1.44E-05	3.77E-06	1.44E-05	3.77E-06
	Ovarian	1.17E-05	2.16E-06	1.17E-05	2.16E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	49,518	13,726	40,000	18,150
	Colorectal	49,518	19,819	40,000	26,945
	NHL	49,518	29,525	40,000	46,984
	Ovarian	49,518	22,888	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, Lux / (kg N emis.*pers*y)		€, 2000 / (kg N emis.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	6.88E-07	7.42E-08	5.55E-07	9.81E-08
	Colorectal	8.39E-07	9.27E-08	6.77E-07	1.26E-07
	NHL	3.85E-07	6.02E-08	3.11E-07	9.59E-08
	Ovarian	3.15E-07	2.68E-08	2.54E-07	4.05E-08
	Total	**2.48E-06**		**2.16E-06**	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	6.88E-07	7.42E-08	5.55E-07	9.81E-08
	Colorectal	8.39E-07	9.27E-08	6.77E-07	1.26E-07
	NHL	3.85E-07	6.02E-08	3.11E-07	9.59E-08
	Ovarian	3.15E-07	2.68E-08	2.54E-07	4.05E-08
	Total	**2.48E-06**		**2.16E-06**	

Table 57: Unit values per kg N/ha, Attert catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / kgN/ha		mg/l NO3 / kgN/ha	
Scenario 1+2. Fertilizer use		0.00298		0.00298	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.00246		0.00246	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	2.56E-05	9.98E-06	2.56E-05	9.98E-06
	Colorectal	3.13E-05	8.64E-06	3.13E-05	8.64E-06
	NHL	1.44E-05	3.77E-06	1.44E-05	3.77E-06
	Ovarian	1.17E-05	2.16E-06	1.17E-05	2.16E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	49,518	13,726	40,000	18,150
	Colorectal	49,518	19,819	40,000	26,945
	NHL	49,518	29,525	40,000	46,984
	Ovarian	49,518	22,888	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, Lux / (kg N/ha*pers*y)		€, 2000 / (kg N/ha*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	3.78E-06	4.08E-07	3.06E-06	5.40E-07
	Colorectal	4.61E-06	5.10E-07	3.73E-06	6.94E-07
	NHL	2.12E-06	3.31E-07	1.71E-06	5.27E-07
	Ovarian	1.73E-06	1.48E-07	1.40E-06	2.23E-07
	Total	**1.36E-05**		**1.19E-05**	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	3.12E-06	3.36E-07	2.52E-06	4.45E-07
	Colorectal	3.80E-06	4.20E-07	3.07E-06	5.72E-07
	NHL	1.75E-06	2.73E-07	1.41E-06	4.35E-07
	Ovarian	1.43E-06	1.22E-07	1.15E-06	1.83E-07
	Total	**1.12E-05**		**9.79E-06**	

Annex III.4 Enza catchment, impact-pathway 4

Table 58: Unit values per kg N applied, Enza catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		0.001102		0.001102	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.000738		0.000738	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.15E-04	4.60E-05	1.15E-04	4.60E-05
	Colorectal	5.07E-05	1.01E-05	5.07E-05	1.01E-05
	NHL	2.47E-05	5.64E-06	2.47E-05	5.64E-06
	Ovarian	4.60E-05	7.74E-06	4.60E-05	7.74E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	47,566	13,185	40,000	18,150
	Colorectal	47,566	19,038	40,000	26,945
	NHL	47,566	28,361	40,000	46,984
	Ovarian	47,566	21,986	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, IT / (kg N appl.*pers*y)		€, 2000 / (kg N appl.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	6.03E-06	6.67E-07	5.07E-06	9.19E-07
	Colorectal	2.66E-06	2.13E-07	2.24E-06	3.01E-07
	NHL	1.30E-06	1.76E-07	1.09E-06	2.92E-07
	Ovarian	2.41E-06	1.87E-07	2.03E-06	2.94E-07
	Total	1.36E-05		1.22E-05	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	4.04E-06	4.47E-07	3.40E-06	6.15E-07
	Colorectal	1.78E-06	1.42E-07	1.50E-06	2.02E-07
	NHL	8.68E-07	1.18E-07	7.30E-07	1.96E-07
	Ovarian	1.62E-06	1.26E-07	1.36E-06	1.97E-07
	Total	9.13E-06		8.19E-06	

Table 59: Unit values per kg N emission, Enza catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		0.00294		0.00294	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.00294		0.00294	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.15E-04	4.60E-05	1.15E-04	4.60E-05
	Colorectal	5.07E-05	1.01E-05	5.07E-05	1.01E-05
	NHL	2.47E-05	5.64E-06	2.47E-05	5.64E-06
	Ovarian	4.60E-05	7.74E-06	4.60E-05	7.74E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	47,566	13,185	40,000	18,150
	Colorectal	47,566	19,038	40,000	26,945
	NHL	47,566	28,361	40,000	46,984
	Ovarian	47,566	21,986	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, IT / (kg N emis.*pers*y)		€, 2000 / (kg N emis.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	1.61E-05	1.78E-06	1.35E-05	2.45E-06
	Colorectal	7.10E-06	5.68E-07	5.97E-06	8.04E-07
	NHL	3.46E-06	4.71E-07	2.91E-06	7.80E-07
	Ovarian	6.44E-06	5.01E-07	5.42E-06	7.87E-07
	Total	**3.64E-05**		**3.27E-05**	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	1.61E-05	1.78E-06	1.35E-05	2.45E-06
	Colorectal	7.10E-06	5.68E-07	5.97E-06	8.04E-07
	NHL	3.46E-06	4.71E-07	2.91E-06	7.80E-07
	Ovarian	6.44E-06	5.01E-07	5.42E-06	7.87E-07
	Total	**3.64E-05**		**3.27E-05**	

Table 60: Unit values per kg N/ha, Enza catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / kgN/ha		mg/l NO3 / kgN/ha	
Scenario 1+2. Fertilizer use		0.0395		0.0395	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.0265		0.0265	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.15E-04	4.60E-05	1.15E-04	4.60E-05
	Colorectal	5.07E-05	1.01E-05	5.07E-05	1.01E-05
	NHL	2.47E-05	5.64E-06	2.47E-05	5.64E-06
	Ovarian	4.60E-05	7.74E-06	4.60E-05	7.74E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	47,566	13,185	40,000	18,150
	Colorectal	47,566	19,038	40,000	26,945
	NHL	47,566	28,361	40,000	46,984
	Ovarian	47,566	21,986	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, IT / (kg N/ha*pers*y)		€, 2000 / (kg N/ha*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	2.16E-04	2.40E-05	1.82E-04	3.30E-05
	Colorectal	9.55E-05	7.64E-06	8.03E-05	1.08E-05
	NHL	4.65E-05	6.33E-06	3.91E-05	1.05E-05
	Ovarian	8.66E-05	6.73E-06	7.28E-05	1.06E-05
	Total	**4.90E-04**		**4.39E-04**	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	1.45E-04	1.60E-05	1.22E-04	2.21E-05
	Colorectal	6.39E-05	5.11E-06	5.38E-05	7.24E-06
	NHL	3.12E-05	4.24E-06	2.62E-05	7.03E-06
	Ovarian	5.80E-05	4.51E-06	4.88E-05	7.08E-06
	Total	**3.28E-04**		**2.94E-04**	

Annex III.5 Ouse catchment, impact-pathway 3

Table 61: Unit values per kg N applied, Ouse catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		0.000427		0.000427	
Scenario 3+4: Arable land from forest		0.000445		0.000445	
Scenario 5+6. Livestock population		0.000553		0.000553	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.04E-04	2.70E-05	1.04E-04	2.70E-05
	Colorectal	4.37E-05	8.75E-06	4.37E-05	8.75E-06
	NHL	2.33E-05	4.71E-06	2.33E-05	4.71E-06
	Ovarian	2.53E-05	4.43E-06	2.53E-05	4.43E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	58,543	16,228	40,000	18,150
	Colorectal	58,543	23,432	40,000	26,945
	NHL	58,543	34,906	40,000	46,984
	Ovarian	58,543	27,060	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, UK / (kg N appl.*pers*y)		€, 2000 / (kg N appl.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	2.59E-06	1.87E-07	1.77E-06	2.09E-07
	Colorectal	1.09E-06	8.75E-08	7.45E-07	1.01E-07
	NHL	5.81E-07	7.01E-08	3.97E-07	9.44E-08
	Ovarian	6.32E-07	5.12E-08	4.32E-07	6.53E-08
	Total	5.28E-06		3.81E-06	
Scenario 3+4. Arable land from forest	Bladder	2.70E-06	1.95E-07	1.84E-06	2.18E-07
	Colorectal	1.14E-06	9.13E-08	7.78E-07	1.05E-07
	NHL	6.07E-07	7.32E-08	4.14E-07	9.85E-08
	Ovarian	6.60E-07	5.34E-08	4.51E-07	6.82E-08
	Total	5.52E-06		3.98E-06	
Scenario 5+6. Livestock population	Bladder	3.35E-06	2.42E-07	2.29E-06	2.71E-07
	Colorectal	1.41E-06	1.13E-07	9.66E-07	1.30E-07
	NHL	7.53E-07	9.09E-08	5.15E-07	1.22E-07
	Ovarian	8.19E-07	6.63E-08	5.59E-07	8.46E-08
	Total	6.85E-06		4.94E-06	

Table 62: Unit values per kg N emission, Ouse catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		0.00147		0.00147	
Scenario 3+4: Arable land from forest		0.00136		0.00136	
Scenario 5+6. Livestock population		0.00146		0.00146	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.04E-04	2.70E-05	1.04E-04	2.70E-05
	Colorectal	4.37E-05	8.75E-06	4.37E-05	8.75E-06
	NHL	2.33E-05	4.71E-06	2.33E-05	4.71E-06
	Ovarian	2.53E-05	4.43E-06	2.53E-05	4.43E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	58,543	16,228	40,000	18,150
	Colorectal	58,543	23,432	40,000	26,945
	NHL	58,543	34,906	40,000	46,984
	Ovarian	58,543	27,060	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, UK / (kg N emis.*pers*y)		€, 2000 / (kg N emis.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	8.89E-06	6.43E-07	6.07E-06	7.19E-07
	Colorectal	3.75E-06	3.01E-07	2.56E-06	3.46E-07
	NHL	2.00E-06	2.41E-07	1.36E-06	3.24E-07
	Ovarian	2.17E-06	1.76E-07	1.48E-06	2.24E-07
	Total	1.82E-05		1.31E-05	
Scenario 3+4. Arable land from forest	Bladder	8.26E-06	5.97E-07	5.64E-06	6.68E-07
	Colorectal	3.48E-06	2.79E-07	2.38E-06	3.21E-07
	NHL	1.86E-06	2.24E-07	1.27E-06	3.01E-07
	Ovarian	2.02E-06	1.63E-07	1.38E-06	2.08E-07
	Total	1.69E-05		1.22E-05	
Scenario 5+6. Livestock population	Bladder	8.87E-06	6.42E-07	6.06E-06	7.18E-07
	Colorectal	3.74E-06	3.00E-07	2.56E-06	3.45E-07
	NHL	1.99E-06	2.41E-07	1.36E-06	3.24E-07
	Ovarian	2.17E-06	1.76E-07	1.48E-06	2.24E-07
	Total	1.81E-05		1.31E-05	

Table 63: Unit values per kg N/ha, Ouse catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / kgN/ha		mg/l NO3 / kgN/ha	
Scenario 1+2. Fertilizer use		0.0843		0.0843	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.1092		0.1092	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.04E-04	2.70E-05	1.04E-04	2.70E-05
	Colorectal	4.37E-05	8.75E-06	4.37E-05	8.75E-06
	NHL	2.33E-05	4.71E-06	2.33E-05	4.71E-06
	Ovarian	2.53E-05	4.43E-06	2.53E-05	4.43E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	58,543	16,228	40,000	18,150
	Colorectal	58,543	23,432	40,000	26,945
	NHL	58,543	34,906	40,000	46,984
	Ovarian	58,543	27,060	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, UK / (kg N/ha*pers*y)		€, 2000 / (kg N/ha*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	5.11E-04	3.69E-05	3.49E-04	4.13E-05
	Colorectal	2.15E-04	1.73E-05	1.47E-04	1.99E-05
	NHL	1.15E-04	1.38E-05	7.84E-05	1.86E-05
	Ovarian	1.25E-04	1.01E-05	8.52E-05	1.29E-05
	Total	1.04E-03		7.52E-04	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	6.62E-04	4.79E-05	4.52E-04	5.35E-05
	Colorectal	2.79E-04	2.24E-05	1.91E-04	2.57E-05
	NHL	1.49E-04	1.79E-05	1.02E-04	2.42E-05
	Ovarian	1.62E-04	1.31E-05	1.10E-04	1.67E-05
	Total	1.35E-03		9.75E-04	

Annex III.6 Vansjø catchment, impact-pathway 3

Table 64: Unit values per kg N applied, Vansjø catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		0.00192		0.00192	
Scenario 3+4: Arable land from forest		0.00342		0.00342	
Scenario 5+6. Livestock population		0.00146		0.00146	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.07E-04	2.76E-05	1.07E-04	2.76E-05
	Colorectal	5.74E-05	1.13E-05	5.74E-05	1.13E-05
	NHL	1.94E-05	3.99E-06	1.94E-05	3.99E-06
	Ovarian	2.32E-05	3.27E-06	2.32E-05	3.27E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	67,178	18,621	40,000	18,150
	Colorectal	67,178	26,888	40,000	26,945
	NHL	67,178	40,055	40,000	46,984
	Ovarian	67,178	31,051	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, NO / (kg N appl.*pers*y)		€, 2000 / (kg N appl.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	1.38E-05	9.89E-07	8.25E-06	9.64E-07
	Colorectal	7.42E-06	5.86E-07	4.42E-06	5.87E-07
	NHL	2.51E-06	3.07E-07	1.49E-06	3.60E-07
	Ovarian	3.00E-06	1.95E-07	1.79E-06	2.17E-07
	Total	2.89E-05		1.81E-05	
Scenario 3+4. Arable land from forest	Bladder	2.46E-05	1.76E-06	1.47E-05	1.72E-06
	Colorectal	1.32E-05	1.04E-06	7.86E-06	1.05E-06
	NHL	4.47E-06	5.47E-07	2.66E-06	6.42E-07
	Ovarian	5.34E-06	3.47E-07	3.18E-06	3.86E-07
	Total	5.14E-05		3.22E-05	
Scenario 5+6. Livestock population	Bladder	1.05E-05	7.52E-07	6.27E-06	7.33E-07
	Colorectal	5.64E-06	4.46E-07	3.36E-06	4.47E-07
	NHL	1.91E-06	2.34E-07	1.14E-06	2.74E-07
	Ovarian	2.28E-06	1.48E-07	1.36E-06	1.65E-07
	Total	2.19E-05		1.37E-05	

Table 65: Unit values per kg N emission, Vansjø catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / t N		mg/l NO3 / t N	
Scenario 1+2. Fertilizer use		0.00437		0.00437	
Scenario 3+4: Arable land from forest		0.00437		0.00437	
Scenario 5+6. Livestock population		0.00437		0.00437	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.07E-04	2.76E-05	1.07E-04	2.76E-05
	Colorectal	5.74E-05	1.13E-05	5.74E-05	1.13E-05
	NHL	1.94E-05	3.99E-06	1.94E-05	3.99E-06
	Ovarian	2.32E-05	3.27E-06	2.32E-05	3.27E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	67,178	18,621	40,000	18,150
	Colorectal	67,178	26,888	40,000	26,945
	NHL	67,178	40,055	40,000	46,984
	Ovarian	67,178	31,051	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, NO / (kg N emis.*pers*y)		€, 2000 / (kg N emis.*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	3.15E-05	2.25E-06	1.87E-05	2.19E-06
	Colorectal	1.69E-05	1.33E-06	1.00E-05	1.33E-06
	NHL	5.70E-06	6.98E-07	3.39E-06	8.19E-07
	Ovarian	6.81E-06	4.43E-07	4.06E-06	4.93E-07
	Total	**6.56E-05**		**4.11E-05**	
Scenario 3+4. Arable land from forest	Bladder	3.14E-05	2.25E-06	1.87E-05	2.19E-06
	Colorectal	1.68E-05	1.33E-06	1.00E-05	1.33E-06
	NHL	5.70E-06	6.98E-07	3.39E-06	8.18E-07
	Ovarian	6.81E-06	4.43E-07	4.05E-06	4.92E-07
	Total	**6.55E-05**		**4.10E-05**	
Scenario 5+6. Livestock population	Bladder	3.15E-05	2.25E-06	1.88E-05	2.19E-06
	Colorectal	1.69E-05	1.33E-06	1.00E-05	1.34E-06
	NHL	5.71E-06	6.99E-07	3.40E-06	8.20E-07
	Ovarian	6.82E-06	4.43E-07	4.06E-06	4.93E-07
	Total	**6.56E-05**		**4.11E-05**	

Table 66: Unit values per kg N/ha, Vansjø catchment.

Scenarios		Catchment specific		Exiopol common	
Dispersion		mg/l NO3 / kgN/ha		mg/l NO3 / kgN/ha	
Scenario 1+2. Fertilizer use		0.0197		0.0197	
Scenario 3+4: Arable land from forest					
Scenario 5+6. Livestock population		0.0150		0.0150	
Dose-response		Mortality	Morbidity	Mortality	Morbidity
All scenarios		YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)	YOLL/ (pers*mg/l NO3*y)	Incidences/ (pers*mg/l NO3*y)
	Bladder	1.07E-04	2.76E-05	1.07E-04	2.76E-05
	Colorectal	5.74E-05	1.13E-05	5.74E-05	1.13E-05
	NHL	1.94E-05	3.99E-06	1.94E-05	3.99E-06
	Ovarian	2.32E-05	3.27E-06	2.32E-05	3.27E-06
Valuation		Mortality	Morbidity	Mortality	Morbidity
All scenarios		€ per YOLL	€ per incidence	€ per YOLL	€ per incidence
	Bladder	67,178	18,621	40,000	18,150
	Colorectal	67,178	26,888	40,000	26,945
	NHL	67,178	40,055	40,000	46,984
	Ovarian	67,178	31,051	40,000	34,537
Unit values		Mortality	Morbidity	Mortality	Morbidity
		€, 2000, NO / (kg N/ha*pers*y)		€, 2000 / (kg N/ha*pers*y)	
Scenario 1+2. Fertilizer use	Bladder	1.42E-04	1.01E-05	8.45E-05	9.88E-06
	Colorectal	7.61E-05	6.01E-06	4.53E-05	6.02E-06
	NHL	2.57E-05	3.15E-06	1.53E-05	3.69E-06
	Ovarian	3.07E-05	2.00E-06	1.83E-05	2.22E-06
	Total	**2.96E-04**		**1.85E-04**	
Scenario 3+4. Arable land from forest	Bladder				
	Colorectal				
	NHL				
	Ovarian				
	Total				
Scenario 5+6. Livestock population	Bladder	1.08E-04	7.71E-06	6.43E-05	7.52E-06
	Colorectal	5.78E-05	4.57E-06	3.44E-05	4.58E-06
	NHL	1.96E-05	2.40E-06	1.16E-05	2.81E-06
	Ovarian	2.34E-05	1.52E-06	1.39E-05	1.69E-06
	Total	**2.25E-04**		**1.41E-04**	