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GREEN ACCOUNTING RESEARCH PROJECT II

SUMMARY FINAL REPORT

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I. OBJECTIVES

The GARPII project extends the research agenda developed under a previous stage (GARPI) that was supported by the JOULE programme of the European Commission during 1994-1996 (JOU2-CT93-0316). The GARP project itself is an application of the methodology developed in the ongoing EC ExternE project regarding the environmental externalities associated with energy and transport. GARPII was initiated with the objective of developing a consistent methodology for the evaluation of environmental accounts in the EU, by examining the impacts of economic activity on other aspects of the economy.

The main objectives of the work programme were:

a) To review the credibility of monetary valuation of environmental damage, as well as that of other indicators of environmental impacts and pressure. The review examined the strengths and weaknesses of the different measures, particularly with reference to their role in developing accounts and in their usefulness to decision-makers. In many areas, the methodology needed to be updated in the light of advances in other areas.

b) To fill the gaps contained in GARPI as much as possible and obtain valuations of environmental damages that are both credible and comparable .

c) To extend the range of pollutants covered by the analysis. In particular, careful consideration was needed of the relationship between primary and secondary pollutants. The effects of heavy metals on human health were also investigated, as were impacts on water and land contamination.

d) To attribute the spatially disaggregated damages to different sources of pollution using a 'multi-source' version of the ECOSENSE model developed by IER, University of Stuttgart. This allowed damages to be assigned to countries and economic activities (sectors), identifying crucial trans-boundary impacts.

e) To critically review the main methodological approaches together with any estimates that were available and comment on how these should be integrated into an accounting system. For each stressor (source of damage) there are a number of defensive expenditures that are undertaken. This issue was identified as important in the first phase, but very sparse data were available.

f) To evaluate the replicability of the methodology to other countries in the EU and consider the feasibility of preparing such estimates on a regular basis so as to form an impression of the changing state of the environment over time. In this regard, the final presentation of the data was an important issue with the prime objective being to maintain a high degree of policy relevance.

II METHODOLOGY

GARPII, like GARPI, mainly focuses on the impacts of air pollution. Airborne pollutants can be distinguished as either primary or secondary, depending on whether they are directly emitted or formed by chemical reactions in the air respectively. Data on these can either be measures or modelled using computer dispersion models.

There are two main elements to the analysis; damage calculation and damage attribution. Damage calculation involves combining pollutant concentration and population maps in order to calculate the value of damage caused by the pollution. Damage attribution allows emissions to be allocated by economic sector. This was done using the ECOSENSE model, a computer model which combines data on technology, emissions, damages caused by exposure to pollutants and valuation data. Both sets of calculations have been undertaken for impacts on human health, crops and building materials.

The analysis allows both physical and monetary indicators of damage to be generated. Where possible one of a number of valuation techniques have been applied to yield estimates for specific endpoints that are closely related to indicators of human health. These estimates have been calculated on the theoretical basis of 'willingness-to-pay' (WTP) or 'willingness-to-accept'(WTA).

For forest and ecosystem impacts the critical load approach was used, with nitrogen being the main pollutant considered. Forest assessment identifies three main types of damage from air pollution: loss of timber, reduced recreational benefits and decreased existence value. All these categories present methodological difficulties, although the situation has improved considerably since the first GARP study. As noted previously, the complexity of these systems does not permit a comprehensive valuation exercise. It has been possible to make some sample valuations, (e.g. for specific biotopes) or obtain some implicit values from related studies.

Global warming impacts were also evaluated. The debate on appropriate quantification of these impacts has advanced considerably in recent years. In GARPI the estimates were made of the present value of future climate change damages in the study countries as a result of global CO_2 emissions in 1990. This was undertaken on the basis of the results of published studies. A revised approach has now been developed which reviews the more recent literature on regional impacts and provides up-dated national damage estimates.

In the case of water pollution, the approach used involved linking data-sets on river water quality, recreational activities and monetary values that exist for these activities to provide estimates of recreational damage costs. The analysis has been undertaken, in the first instance, for the UK. Land contamination issues are likely to be very specific. In accordance with the approach taken in the rest of the project, the ideal approach would be to create 'flow' accounts to assess the change in the value of contaminated land over time. However, initial investigations of the data indicated that this would not be possible. Hence, data on the stock of contaminated land together with illustrative figures on the costs of remediation were collected. For both these types of impacts it has only been possible, at this stage, to make some sample valuations. It is hoped, particularly in the case of water impacts, that the methodology could be expanded to become more comprehensive – expanding the quantification of the impact pathway so that the analysis is more in line with that for air pollution.

On the issue of whether the techniques outlined above are appropriate, some recent developments, like the "Green Stamp" project funded by DGXII1, have called into question the feasibility of applying the valuation techniques of willingness-to-pay and willingness-to-accept. The "Green Stamp" project focuses on the issue of using avoidance cost data for monetising environmental effects rather than willingness-to-pay. Whilst the Green Stamp Approach is useful to policy makers, it does not obviate the need for damage estimation. This issue is examined in greater depth in Section VI of this report.

1 Produced under Contract number EV5V-CT94-0363. For further details see *From research to implementation: policy-driven methods for evaluating macroeconomic environmental performance.* Proceedings of Luxembourg meeting, 1999. ISBN 92-828-5964-21.

III MAIN RESULTS

Revised Estimates of Impacts and Damage Costs Using Measured Concentration Data

Table 1 shows, ordered by the impact categories mortality, morbidity, crops, and material, the damage costs estimated for the countries of study, Germany, Italy, the Netherlands, and the United Kingdom. Base years for the calculations are 1994 for Germany, Italy, and the Netherlands and 1996 for the UK.

The pollutants which were taken into account were SO_2, PM_{10}, and O_3 with some exceptions. For some pollutants exceedances of critical levels could be assessed. Measured concentration data were used to estimate environmental effects occurring in the respective country in a specific year. This is in contrast to the attribution results below which were derived by applying the modelling approach outlined in the methodology section.

The health damages represent by far the largest share of damage costs in each country. The major contribution is estimated for three impacts caused by PM_{10}, namely chronic mortality, chronic bronchitis, and restricted activity days

Ozone is the major contributor to damages on field crops for Germany, the Netherlands, and the UK. As no O_3 was taken into account for the Italian study, the amount of damage costs assessed for crops in Italy is very low. Concerning material damages the most damage costs were observed for the UK which are dominated by effects caused by SO_2.

The results show that damage costs amount to 2.8% of GDP for Germany, 4.4% of GDP for Italy, 3.9% for the Netherlands and 2.0% for the UK in 1994. GARPI estimated that the damages in 1990 were 4.1% of GDP for Italy, 5% for the Netherlands and 3.3% for the UK. These are not directly comparable as changes in the damage costs to these countries, due to changes in the exposure response functions and valuation methods. They do, however, give a broad indication of the different results given by the two projects, showing that on the whole the damages indicated in GARPI were of a higher order than those in GARPII, Italy being the exception. For Germany, such comparisons are not useful in that the GARPI study focused only on West Germany, and the results obtained in GARPI were incomplete owing to the difficulty of data collection.

Impacts and Damage Costs Caused by the Economic Sectors of the Countries: Germany, Italy, Netherlands and UK.

Table 2 shows the damage costs caused by the individual economic sectors of the four countries, Germany, Italy, the Netherlands, and the UK, classified by impact categories. The effects on human health clearly dominate the damage costs. The main contributors to the damage costs for German emissions are the economic sectors 'Public Power,' 'Commercial, Combustion Plants', 'Road Transport' and 'Agriculture'. Similar situations are observed for the emissions of the remaining three countries. The public power, co-generation and district heating plants produce the highest level of damages compared to GDP for three nations, the Netherlands being the only exception, with agriculture being most important in that country. Industrial combustion is equally significant in Germany.

For Germany, Italy and the UK all damage costs estimated for the emissions of the sector 'Solvent Use' are related to ozone concentrations. For German emissions these represent at the same time the largest part of all damages caused by O_3 so that it can be easily seen in Table 2 that O_3 related damages are not very important for the total amount of damage costs. O3 related damages could not be included for the estimates of damage import and export within the EU.

Table 1: Damage Costs caused by the pollutants SO_2, PM_{10} and O_3 in Germany, Italy, the Netherlands, and UK. The considered background levels were PM_{10}: 10 µg/m^3, O_3: 20 ppbV (AOT40 crops: 0 ppbVh), SO_2: 1ppbV.

	GERMANY	ITALY [a]	NETHERLANDS [b]	UNITED KINGDOM [c]
	Damage Costs [Million EURO[d]/a] unless otherwise stated: Base year 1990			
Human Health				
Mortality	22191	22564	5084	7952
Morbidity	21157	21936	4926	7932
Subtotal	43348	44500	10010	15884
Percentage of GDP[e] [%]	2.73%	4.41%	1.9%	1.75%
Costs Per Inhabitant [EURO/(person*a)]	532	778	651	272
Crops				
Subtotal	1611	2.2	154	754
Percentage of GDP [%]	0.10%	2 e-4%	0.06%	0.08%
Costs Per Inhabitant [EURO/(person*a)]	20	4e-2	10	13
Material				
Subtotal	136	N.A.	10	1250
Percentage of GDP [%]	0.01%	N.A.	3.8e-3%	0.14%
Costs Per Inhabitant [EURO/(person*a)]	2	N.A.	1	21
Total	45094	44502	10174	17888
Percentage of GDP [%]	2.8%	4.4%	3.9%	2.0%
Costs Per Inhabitant [EURO/(person*a)]	554	778	662	306

Notes

[a] Results for Italy do not include damages due to O_3 and material impacts

[b] Results for the Netherlands include morbidity impacts of CO at 1.8 million EURO/a (assumed background for CO: 0.15 ppbV), Wet acid deposition was assumed to the average value of 100 meq/m^{2}a

[c] Results for the UK include material damages due to Acidity

[d] in 1995 prices

[e] [European Commission 1997a, EC: Eurostat 1997]

Table 2 Estimated damages caused by German, Italian, the Netherlands', and the UK's economic activities.

Receptor	Damages [million EURO]										
	Public Power, Cogeneration, District heating Plants	Commercial, Institutional and Residential Combustion Plants	Industrial Combustion	(Non combustion) Production Processes	Extraction and Distribution of Fuels	Solvent Use	Road Transport	Other Mobile Sources and Machinery	Waste Treatment and Disposal	Agriculture	**All Economic Sectors**
German Emissions											
Material	510	120	490	17	2.7	N.A.	120	19	N.A.	200	**1700**
Crops	9.3	55	-43	61	110	640	400	-34	N.A.	-37	**1100**
Morbidity	5700	1500	5800	230	82	170	4700	660	N.A.	5000	**24000**
Mortality (3% d. r.)	6600	1700	6800	270	110	270	4700	670	N.A.	5100	**26000**
Total damages	**13000**	**3400**	**13000**	**580**	**310**	**1100**	**9900**	**1300**	**N.A.**	**10000**	**53000**
% of GDP	**0.819**	**0.214**	**0.819**	**0.037**	**0.020**	**0.069**	**0.623**	**0.082**	**N.A.**	**0.630**	**3.338**
Damage Export [%]	**64**	**59**	**58**	**52**	**60**	**64**	**54**	**56**	**N.A.**	**44**	**58**
Italian Emissions											
Material	150	19	96	18	2.0e-2	N.A.	100	32	6.8	110	**520**
Crops	-14	3.7	-6.9	23	35	140	290	25	27	-39	**470**
Morbidity	2700	350	1900	320	13	50	2900	820	160	1900	**11000**
Mortality (3% d. r.)	3100	390	2100	360	21	83	3000	850	15	2000	**12000**
Total damages	**5900**	**770**	**4100**	**720**	**69**	**280**	**6300**	**1700**	**210**	**4000**	**24000**
% of GDP	**0.585**	**0.076**	**0.406**	**0.071**	**0.007**	**0.028**	**0.624**	**0.168**	**0.021**	**0.396**	**2.378**
Damage Export [%]	**61**	**65**	**63**	**53**	**34**	**34**	**62**	**64**	**54**	**41**	**59**
Netherlands' Emissions											
Material	14	3.1	11	20	0.12	0.11	22	6.2	1.3	69	**140**
Crops	-43	-10	-22	-1.5	-0.33	65	-49	-18	-1.7	-16	**-98**
Morbidity	250	72	180	320	3.3	21	600	130	22	1000	**2500**
Mortality (3% d. r.)	270	72	200	360	3.2	30	600	140	-1.4	1000	**2600**
Total damages	**490**	**140**	**360**	**700**	**6.3**	**120**	**1200**	**260**	**20**	**2100**	**5200**
% of GDP	**0.189**	**0.054**	**0.139**	**0.270**	**0.002**	**0.046**	**0.463**	**0.103**	**0.008**	**0.810**	**2.006**
Damage Export [%]	**81**	**85**	**79**	**79**	**87**	**92**	**87**	**80**	**79**	**80**	**83**
UK's Emissions											
Material	890	75	230	12	2.7	N.A.	83	21	1.5	96	**1400**
Crops	-270	-29	-71	76	98	210	-120	-51	8.4	-45	**-220**
Morbidity	5100	490	1300	140	120	79	2200	310	35	1500	**11000**
Mortality (3% d. r.)	6000	540	1500	190	170	190	2000	290	6.7	1500	**13000**
Total damages	**12000**	**1100**	**2900**	**410**	**400**	**470**	**4200**	**560**	**52**	**3000**	**25000**
% of GDP	**1.322**	**0.121**	**0.320**	**0.045**	**0.044**	**0.052**	**0.463**	**0.062**	**0.006**	**0.331**	**2.754**
Damage Export [%]	**50**	**48**	**46**	**56**	**66**	**76**	**54**	**47**	**61**	**33**	**52**

Note that SO2, Nox, NH3 and NMVOS emissions are considered. The German results also include PM10.

Attribution of Impacts and Damage Costs to Source Countries within the European Union

Table 3 shows the estimated attributions of damages caused within the EU-15 states. It can be seen that most of the approximately 130 billion EURO/a damage costs that occur within the EU are received and caused by Germany, France, UK, and Italy. Because 1990 is the base year, it is worth noting, for example, that the high attribution to agriculture in the Netherlands is likely to have fallen significantly in the subsequent period. It is now therefore more likely to be comparable to the other countries.

'Net imports' of damages are calculated by diminishing the damage costs occurring within one country (grey row) by the corresponding damage costs effected by the same country within the EU (first grey column). The country identifiers for net importers are highlighted in the table, while the background for net exporters is darkened.

The results show that often less than fifty percent of the damages which occur in the country are effected by its own emissions. This is especially the case for small countries with many EU member states in the neighbourhood (e.g. the Netherlands) while in large countries and countries with less EU neighbours most of the damages inside the countries are caused by their own emissions (e.g. Germany, Greece).

Table 3 Attribution of damage costs within the EU in 1990.

Source Countries	Receptor Countries: AT	BE	DE	DK	ES	FI	FR	GR	IE	IT	LU	NL	PT	SE	UK	EU	Non EU
	Damage Costs caused by the Source Countries within the Receptor Countries [billion ECU/a]																
EU	**2.8**	**4.5**	**40.9**	**2.3**	**8.9**	**0.4**	**21.4**	**2.0**	**0.4**	**15.3**	**0.1**	**7.0**	**1.2**	**2.1**	**19.4**	**128.8**	**34.9**
	Percentage of Damage Costs Caused in the Receptor Countries [%]															[bn ECU/a]	
AT	**12.2**	0.2	0.9	0.6	0.2	0.9	0.2	0.9	0.1	2.2	0.3	0.2	0.0	0.8	0.1	**1.2**	**1.8**
BE	1.1	**12.3**	3.7	3.8	1.2	1.4	3.7	0.0	1.4	0.7	4.8	13.0	0.4	2.6	1.1	**4.4**	**0.4**
DE	47.0	14.2	**53.8**	43.7	4.8	38.7	13.4	2.0	6.9	15.6	33.3	15.6	0.9	49.6	6.7	**34.4**	**17.0**
DK	0.6	1.0	0.9	**9.2**	0.1	4.6	0.5	0.0	0.6	0.1	0.8	1.0	0.0	8.9	0.8	**1.2**	**0.4**
ES	1.7	8.6	3.8	1.8	**51.8**	0.0	16.3	0.0	16.1	5.6	8.9	6.1	50.4	1.0	7.3	**13.5**	**0.4**
FI	0.1	0.1	0.1	0.4	0.0	**29.5**	0.0	0.0	0.1	0.0	0.0	0.1	0.0	1.9	0.1	**0.3**	**0.1**
FR	8.7	33.5	15.3	7.2	16.8	2.1	**36.2**	0.1	11.2	10.3	31.9	23.8	5.9	5.4	11.4	**23.2**	**2.0**
GR	1.1	0.0	0.1	0.2	0.1	0.0	0.1	**78.0**	0.1	2.3	0.1	0.0	0.0	0.2	0.0	**2.1**	**3.7**
IE	0.0	0.3	0.2	0.5	0.4	0.1	0.4	0.0	**18.8**	0.0	0.2	0.4	0.3	0.2	2.1	**0.7**	**0.0**
IT	23.3	3.0	6.9	2.5	8.8	1.6	5.9	18.9	2.8	**60.1**	4.1	2.4	2.6	2.8	1.2	**15.8**	**6.8**
LU	0.2	0.3	0.4	0.2	0.1	0.1	0.2	0.0	0.1	0.1	**1.6**	0.4	0.0	0.1	0.0	**0.3**	**0.0**
NL	1.2	8.0	4.6	7.1	1.0	2.3	3.8	0.0	1.4	0.6	5.6	**13.8**	0.3	5.0	1.8	**4.9**	**0.5**
PT	0.0	0.6	0.2	0.1	6.8	0.0	1.1	0.0	2.4	0.1	0.6	0.4	**36.0**	0.0	0.7	**1.6**	**0.0**
SE	0.2	0.3	0.4	1.5	0.0	11.7	0.1	0.0	0.2	0.0	0.2	0.3	0.0	**8.1**	0.3	**0.5**	**0.3**
UK	2.6	17.5	8.6	21.2	8.0	7.0	18.1	0.0	37.8	2.0	7.7	22.4	3.3	13.4	**66.5**	**24.7**	**1.2**

Water Pollution and Industry

The effects of different industrial sectors on water pollutant levels in Italy and Germany have been estimated. For the Netherlands and the UK data were limited.

In both Germany and Italy approximately 62% of organic water pollution is generated by industrial sectors, the remaining 38% being due to civil water discharges. Among the industrial sectors, the most polluting is food and beverages (30% and 24% of the total in Germany and Italy respectively), followed by chemical industry (16% and 11%) and paper industry (8% and 7%). In Italy the textile sector is also quite important, accounting for 5% of the total organic pollution. In the Netherlands, figures of 15,382, 12,625 and 5,630 people-equivalent are reported for consumers, producers and other polluters' pollution loads respectively.

Water Pollution and Angling
A preliminary estimate was made of the effects of poor water quality on angling recreation values for the UK, covering both coarse and game fishing. The total damages to UK angling from poor water quality (and, by assumption, poor fish stocks, were valued at 27.8 million EURO (June 1997 prices), or 0.003% of GDP.

Effect of Waterfront Location on Amenity Values
For the UK, the amenity value of waterfront properties it was estimated that the annualised value was between 3.2 million EURO and 24.2 million EURO[2], depending on the premium applied to the house price. This suggests that the effect on house prices of water frontage is quite substantial. It must be noted, however, that the values given here are not an indicator of the level of price premium applied to houses by water quality, rather they simply indicate the presence of water. As a percentage of 1997 GDP, the amenity value of waterfront properties ranged from 0.0003% to 0.0024%, depending upon the premium applied.

Expenditures on Contaminated Land
Following a survey, it was found that current remediation expenditure is 0.09% of GDP in the UK and 0.07% of GDP for the Netherlands. Data for Italy and Germany were not available.

Global Warming Damages
The damages caused by CO2 and other gases were estimated, based on a methodology proposed for the EC ExternE project. However, the uncertainty around these estimates is still of such an order of magnitude that there is less value in presenting these in a way comparable with the other damage category estimates presented in GARP and we do not do so in this summary report. If future research reduces the uncertainty around CO2 damage estimates there is no methodological problem in including such estimates in the GARP accounting framework

IV SCIENTIFIC INTEREST AND NOVELTY

The scientific interest of this research consists in the elaboration of a consistent methodology for the assessment of the damage caused by pollution to stocks at risk, as well as the calculation of the damage both in physical and monetary terms. The monetary approach to green accounting has been further developed in the framework of GARPII, highlighting possible areas of integration with a physical approach.

A specific example of this is that for the assessment of air pollution damage to crops, the Dutch team co-operated with the Dutch Agricultural Economics Research Institute (LEI-DLO) to account for endogenous price effects, substitution of cropping activities, and (spatially) differential impacts on producers and consumers. To this effect, the Dutch team and LEI-DLO adjusted an existing price-endogenous, comparative static, spatial equilibrium model of the Dutch farm sector (DRAM) to accommodate air pollution-crop yield interactions. The results of this exercise not only provided a more "correct" estimation of economic damage, they also showed the distribution of damages between 1) producers and consumers, 2) between different sub-sectors in agriculture, and 3) between different regions in the Netherlands.

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2 based on a 25 year period and a 6% discount rate

V POLICY RELEVANCE

The purpose of the GARP exercise is to investigate the scope and applicability of the impact-pathway and damage cost methodology to the development of environmental accounting. This is useful for policy makers in that GARP provides for a more complete estimation of the damages caused by emissions, meaning that policies can be more effectively targeted towards those pollutants with the greatest damages.

The attribution of damages by economic sector and country of origin is also of great relevance to policy. Identifying polluting industries will facilitate the easier internalisation of pollution costs in production, leading to the establishment of incentives to move away from heavily polluting industry. The establishment of the country of origin of pollution will enable greater cross-border co-operation in reducing emissions to levels where the full cost of production is taken into consideration.

Policy makers should also take note of the water pollution damages attributable to industry. This is of particular relevance when setting targets for reducing pollution levels and when constructing instruments to achieve these targets. It must be noted that further research in this area is needed.

The GARP exercise has developed a number of methodologies that can and do help decision makers to be more confident that policy initiatives will be targeted on the basis of pollutant attribution and in correct measure. This is most advanced in the case of air pollution where the modelling work undertaken has had wide application in the design of air quality strategy. The results obtained for water and land, whilst being preliminary, also provide a useful indication as to how priorities should develop in these areas.

Applications to environmental accounting are more straightforward than in many other policy contexts for air and water due to the fact that temporal changes in environmental impacts are likely to have greater robustness than absolute damages. This is partly because willingness to pay valuations and physical measures of environmental impact are, at present, most easily defined over more incremental-type changes whereas absolute damages from human activity are difficult to isolate accurately. It should be possible to establish a core European monitoring team to undertake periodic reporting of damage costs in the form of satellite accounts. This could come into effect immediately.

Methodologies for the inclusion of water and land in an environmental accounting framework are not sufficiently developed at this stage to allow the recommendation of the adoption of satellite accounts at this point. In both cases there is a need for standardisation and centralisation of databases that would allow reporting procedures to be established. Further research will ensure that methodological developments could parallel and inform this data gathering exercise. In turn, this should allow the formation of satellite accounts.

The GARP exercise has attempted to apply welfare-theoretic willingness to pay valuation measures to the physical environmental impacts in order to present damages in monetary terms. Where possible, this is the most appropriate and meaningful way to express damage costs. It may be, however, that where damages are non-marginal or very complex in their effect, avoidance costs incurred can be used as a minimum for willingness-to-pay valuation. This is likely to be the case with some types of ecosystem damage and global warming impacts. Avoidance costs are, of course, useful to policy makers in their own right. In the context of environmental accounting, however, these costs should only be used as a lower bound monetary indicator for WTP where other willingness to pay measures are clearly invalid due to methodological difficulties or insufficient data. Future developments in environmental accounting should recognise the strengths and weaknesses of these two monetary indicators, be explicit in stating their demand-side or supply-side origin, and adopt them according to the context.

VI. LIST OF PUBLICATIONS

Contribution to books - Published

Markandya, A and I Milborrow, "Green Accounting Research Project" in *UK Environmental Accounts 1998*. Office for National Statistics. TSO, London 1998.

Articles

Kuik, O.J., F.A. Spaninks, C. Dorland, J.F.M. Helming (1999) "An Economic Assessment of the Benefits of Ozone Control to Agriculture in the Netherlands", forthcoming in *European Review of Agricultural Economics*, Mouton, The Hague [etc.].

Kuik, O.J., C.Dorland, H.M.A. Jansen (forthcoming) *Monetarisering van Baten van Milieubeleid: Een Verkennend Onderzoek (Monetarization of the Benefits of Environmental Policy: a Review, in Dutch)*, Ministry of Economic Affairs, The Hague.

Friedrich, R., Droste-Franke, B. and Krewitt, W. (1999) "The Impact-Pathway approach as methodology for the impact assessment in a green accounting framework", in *Proceedings of the joint workshop "From research to implementation: policy-driven methods for evaluating macro-economic environmental performance", Luxembourg, 28-29/9/98*, DG XI, DG XII and Eurostat in co-operation with the European Environment Agency, Brussels.