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ACCOUNTING FOR SUSTAINABLE DEVELOPMENT: THE NAMEA-BASED APPROACH

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1. Introduction

Accounting for sustainable development requires a broadening of scope of the conventional System of National Accounts (SNA; United Nations *et al.*, 1993). This wider perspective is necessary to account for the priceless environmental and social externalities, which are important in a sustainable development context. This paper's focus is on the Dutch National Accounting Matrix including Environmental Accounts (NAMEA; cf. De Haan and Keuning, 1996), which extends the SNA with physical flow accounts. The NAMEA is published by *Statistics Netherlands* every year. The environmental accounts show the interactions between producer and consumer (household) activities and the natural environment. These interrelationships occur as a consequence of the environmental requirements of these activities: natural resource inputs and residual outputs. These requirements are appointed to these activities when and where they actually take place. This direct recording is consistent with prevailing national accounting practices.

By providing economic and environmental data in a consistent Leontief-type framework, the NAMEA is particularly suited for analytical purposes. This paper discusses various analytical applications that are directly related to sustainability policy issues, such as decoupling environmental pressures from economic growth. The systems approach of the NAMEA allows sustainability issues to be considered from two different perspectives. The first perspective takes the activities of producers and consumers (households) as a reference. The second perspective, which is particularly relevant for open economies, grasps sustainability issues by taking domestic demand for goods and services as the point of departure. This approach shifts the focus from the activities to the goods consumed. This second perspective can be analytically deduced from the first by taking the environmental consequences of international trade into account. Policy measures derived from the first approach are directed towards the sustainable performance of activities on the production side. In the second approach they aim at realizing sustainable consumption patterns or lifestyles. Both perspectives and both kinds of policy measures are of course useful in addressing and enhancing sustainable development.

Another relevant national accounting module is the Social Accounting Matrix (SAM; United Nations *et al.*, 1993, pp. 461-88). A SAM elaborates on the interrelationships between economic and social statistics by incorporating information on labour and households in the national accounts. Expanding the SNA with NAMEA and SAM yields a consistent and linked set of indicators that are useful for analyzing interactions between the different dimensions of sustainability.

This paper proceeds as follows. Section 2 discusses the accounts of the NAMEA. Section 3 presents NAMEA-based analyses of producer and consumer activities and international trade. Section 4 concludes.

2. The NAMEA

The NAMEA consists of a National Accounting Matrix (NAM) extended with Environmental Accounts. All accounts are presented in matrix format. This format reconciles supply-use tables and sector accounts, creating a comprehensive accounting framework that can be presented at various levels of detail. The economic accounts in the NAM-part of the NAMEA present the complete set of accounts of the SNA. This part, however, is slightly different from standard SNA practices. These differences relate to a regrouping of transactions which accommodate either its linkage to the environmental accounts or enhance a clear representation of transactions that are relevant from an environmental perspective. For example, transactions directly related to environmental management, such as environmental protection expenditures and environmental taxation and subsidies, are explicitly shown in the economic accounts.

The environmental accounts in the NAMEA are denominated in physical units and focus on the consistent presentation of material input of natural resources and output of residuals for the national economy. These inputs and outputs are the environmental requirements of the economy. Environmental requirements generally are not related to market transactions, and therefore they are not represented in the standard national accounts. By the presentation of the economic accounts in monetary terms and the environmental accounts in the most relevant physical units, the NAMEA maintains a strict borderline between the economic sphere and the natural environment. The NAM is extended with two accounts on the environment: a substances account (account 11) and an environmental themes account (account 12).

2a. Substances account

The substances account provides information on the physical exchanges between the economy and the natural environment. It systematically determines the origin (in the column) and destination (in the row) of ten types of pollutants. Table 1 provides a detailed overview of the origin, and table 2 of the destination, of these substance flows in the 1997 NAMEA for the Netherlands.

Table 1 distinguishes between residuals originating from consumers, producers and other sources. Taken together, these outputs constitute the gross emissions by residents. These figures for the emission by residents of a particular country are important for assigning the responsibility of pollution to particular countries. For example, the NAMEA greenhouse gas emissions by residents include emissions resulting from international transport activities. De Haan and Verduin (2000) point out that this measure would be a much better focus in international emission reduction agreements than the usual greenhouse gas inventory, which disregards international transport. A registration by residents is also necessary for linking in a meaningful way the environmental data with the economic data, which are recorded according to the same resident principle.

The figures for emissions by residents may differ substantially from those for emissions in the Netherlands. When considering the effects of pollution, the latter data are relevant only for those substances that contribute to regional environmental problems. For substances that exert an effect only on global environmental worries like climate change or ozone layer depletion, a country's perspective is not relevant. This is the reason why emission transfers from and to the rest of the world (ROW) are reported only for the substances that accumulate on a regional scale in the natural environment (tables 1 and 2, columns 11e-11i; data on international waste flows are not yet available). For these substances, table 3 shows the relationship between emissions by Dutch residents and the accumulation of these substances in the Netherlands. The table is derived from tables 1 and 2. Table 3 shows that the emissions to the ROW exceed those from the ROW. This implies that the accumulation on national territory is smaller than the net emissions by residents. This is especially true for NO_x and SO_2 with differences of 85% and 59%, respectively.From tables 1 and 2 it can be seen that the emissions to and from the ROW are dominated by transfers by surface water or air. The exception is the emission of SO_2 to the ROW, which is mainly caused by residents. The substantial emissions of NO_x and SO_2 by residents in the ROW are mainly caused by transport activities, especially by water transport. This is a reflection of the importance of the transport sector for the Dutch economy. Evidence for the significance of this sector can also be found in the (not shown) substantial share of mobile sources in total NO_x and SO_2 pollution by Dutch residents in 1997: 77.1% and 59.9%, respectively.

2b. Environmental themes account

Just as the balancing items of the accounts in the NAM-part of the NAMEA provide important economic indicators, the balancing item of the substances account provides a relevant environmental indicator: the contribution of pollutants to environmental themes. This balancing item equals the total amount of substan-

Table 1. Detailed presentation of the origin of substance flows in the NAMEA of 1997 (column-account *11*).

	CO_2	N_2O	CH_4	CFCs and halons	NO_x	SO_2	NH_3	P	N	Waste	Natural gas	Crude oil
	11a	11b	11c	11d	11e	11f	11g	11h	11i	11j	11k	11l
	mln kg			*1 000 kg*	*mln kg*						*petajoules*	
EMISSION BY CONSUMERS	36 790	3.53	21.17	45	109.42	2.05	6.77	8.64	115.44	5 120		
Own transport	15 640	3.32	3.99	-	87.61	1.52	-	-	25.50	70		
Other purposes	21 150	0.21	17.18	45	21.81	0.53	6.77	8.64	89.94	5 050		
EMISSION BY PRODUCERS	163 270	69.32	618.58	803	591.09	234.08	180.89	84.49	903.37	10 050		
Agriculture and forestry	9 230	26.32	448.95	5	32.51	1.75	176.50	53.01	612.79	860		
Fishing	3 760	0.88	0.13	-	77.31	63.11	-	-	19.81	110		
Crude petroleum and natural gas production	250	0.02	0.08	-	1.00	0.35	0.15	-	0.50	90		
Other mining and quarrying	1 820	0.01	157.57	-	3.20	0.17	-	-	1.17	100		
Manufacture of food products, beverages and tobacco	4 520	0.07	0.34	20	6.99	0.48	0.23	2.54	15.46	460		
Manufacture of textile and leather products	420	0.01	0.05	-	0.58	0.01	0.01	0.03	1.95	50		
Manufacture of paper and paper products	1 930	0.01	0.08	-	2.18	0.08	0.10	0.82	4.33	360		
Publishing and printing	310	0.02	0.04	-	1.07	0.03	-	-	0.41	90		
Manufacture of petroleum products	11 200	0.07	0.60	-	15.53	52.14	0.02	0.01	5.99	70		
Manufacture of chemical products	22 470	35.06	3.11	231	27.65	12.22	2.77	7.51	19.37	1 980		
Manufacture of rubber and plastic products	250	0.01	0.04	-	0.41	0.01	-	0.02	0.27	90		
Manufacture of basic metals	8 870	0.01	0.09	-	9.35	10.09	0.07	0.17	3.98	110		
Manufacture of fabricated metal products	530	0.03	0.04	-	1.42	0.04	-	0.02	1.33	80		
Manufacture of machinery n.e.c.	380	0.02	0.04	-	1.03	0.03	-	0.07	0.90	80		
Manufacture of electrical equipment	1 140	0.01	0.11	-	1.79	0.35	0.01	0.02	1.10	90		
Manufacture of transport equipment	170	0.01	0.07	1	0.44	0.02	-	-	0.86	70		
Recycling industries	370	-	-	78	0.15	-	-	-	0.00	740		
Manufacture of wood and wood products	80	0.01	0.01	-	0.34	0.01	-	-	1.13	40		
Manufacture of construction materials	3 150	0.02	0.29	-	11.93	3.85	0.50	0.05	5.84	180		
Other manufacturing	300	0.02	0.03	-	0.61	0.04	-	-	1.34	120		
Electricity supply	44 400	0.35	1.23	-	44.33	12.46	-	0.03	21.81	50		
Gas and water supply	50	-	1.95	-	0.15	0.02	-	-	0.03	30		
Construction	1 910	0.40	0.25	225	21.38	1.44	-	2.95	8.83	1 330		
Trade and repair of motor vehicles	660	0.04	0.02	-	1.85	0.06	-	-	0.99	100		
Wholesale trade	1 890	0.30	0.13	6	12.30	0.33	-	0.04	4.22	170		
Retail trade, repair (excl. motor vehicles), hotels and restaurants	2 280	0.04	0.02	11	2.73	0.06	-	0.01	1.51	140		
Land transport	7 560	1.83	0.44	-	87.62	2.31	-	-	27.62	90		
Water transport	6 440	1.51	0.24	-	129.32	57.95	-	-	35.46	610		
Air transport	10 290	0.06	0.11	-	38.63	0.85	-	-	9.82	20		
Supporting transport activities	390	0.05	0.03	1	3.84	0.27	-	-	1.45	50		
Financial, business services and								-				
communication	4 030	0.58	0.50	-	20.46	0.67	0.53	-	8.56	510		
Public administration and social security	2 710	0.32	0.12	-	21.88	11.39	-	-	6.22	180		
Education	870	0.04	0.12	-	1.37	0.01	-	-	0.44	70		
Health and social work activities	1 730	0.43	0.22	-	2.03	0.39	-	-	0.62	130		
Sewage and refuse disposal services	5 590	0.72	1.40	225	4.87	1.05	0.02	17.21	76.26	740		
Other services	1 320	0.07	0.11	-	2.82	0.04	-	-	1.00	60		
OTHER DOMESTIC ORIGIN												
Waste dumping sites	960	-	464.06	33	0.31	0.02	-					
Transport differences								6.62	15.66			
Emission by residents	201 020	72.85	1103.81	881	700.82	236.15	187.66	99.75	1034.47	15 170		
FROM THE REST OF THE WORLD												
Non-residents in the Netherlands					41.01	12.00	-	-	11.25	.		
Transfer by surface water or air					59.80	70.40	22.10	15.00	313.41			
OTHER CHANGES OF NATURAL RESOURCES											3 364	250
Total = NAMEA colomn total 11	201 020	72.85	1103.81	881	801.63	318.54	209.76	114.75	1359.12	15 170	3 364	250

Source: Statistics Netherlands, 2000

Table 2. Detailed presentation of the destination of substance flows in the NAMEA of 1997 (row-account *11*).

	CO_2	N_2O	CH_4	CFCs and halons	NO_x	SO_2	NH_3	P	N	Waste	Natural gas	Crude oil
	11a	11b	11c	11d	11e	11f	11g	11h	11i	11j	11k	11l
	mln kg			*1 000 kg*	*mln kg*						*petajoules*	
ABSORPTION BY PRODUCERS												
Agriculture								1.09	5.41			
Crude petroleum and natural gas production											2 541	88
Construction								3.00	3.00			
Sewage and refuse disposal services								17.18	109.50	4 460		
TO THE REST OF THE WORLD												
Residents in the rest of the world					282.31	130.70	-	-	79.20	.		
Transfer by surface water or air					411.68	92.15	34.00	16.00	424.51			
CONTRIBUTION TO ENVIRONMENTAL THEMES												
Greenhouse effect	201 020	72.85	1103.81									
Ozone layer depletion				881								
Acidification					107.64	95.70	175.76					
Eutrophication								77.47	737.50			
Waste										10 710		
Changes in natural resources											823	162
Total = NAMEA row total 11	201 020	72.85	1103.81	881	801.63	318.54	209.76	114.75	1359.12	15 170	3 364	250

Source: Statistics Netherlands, 2000

Table 3. Net emissions by residents and net accumulation on national territory, 1997.

	NO_x	SO_2	NH_3	P	N
	mln kg				
Emissions by consumers	109	2	7	9	115
Emissions by producers	591	234	181	84	903
Emissions by other sources	0	0	-	7	16
Gross emissions by residents	701	236	188	100	1034
Absorption by producers (-)	-	-	-	21	118
Net emissions by residents	**701**	**236**	**188**	**78**	**917**
Emission transfers from the ROW	101	82	22	15	325
Emission transfers to the ROW	694	223	34	16	504
Net accumulation on national territory	**108**	**96**	**176**	**77**	**738**

Source: Statistics Netherlands, 2000

ces originating from the various sources in the column minus the other destinations in the row. For CO_2, N_2O, CH_4 and CFCs/halons this balance is equal to the emission by residents. For NO_x, SO_2, NH_3, P, N and waste it corresponds to the net accumulation on national territory. For natural gas and crude oil it equals ‘other changes of natural resources’, which includes additions to proven reserves, minus ‘absorption by producers', which registers extractions. The environmental themes were introduced by De Haan *et al.* (1994) to surpass the measurement problems related to the impacts of environmental degradation. The themes-oriented representation of environmental pressures is particularly useful for the formulation of policy goals with respect to these pressures.

The balance in the row of the substances account of the NAMEA is at the same time an element of the column of the environmental themes account. This latter account aggregates with conversion factors the various substances, which contribute to the same theme, into environmental theme-indicators. The environmental themes establish a link between pressures on the environment and its state. They reflect the mechanisms by which specific pressures are related to particular environmental damages. A direct link is often difficult to establish. For example, in the case where the environmental damage manifests itself only if a specific threshold is exceeded. Table 4 shows in bold summary indicators, which are present in the row of the environmental themes account.

The NAMEA contains two environmental themes that address global environmental problems: the greenhouse effect and ozone layer depletion. The greenhouse-effect theme relates to the danger of climate change caused by a concentration of greenhouse gases in the atmosphere. The greenhouse gases include carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). The ozone-layer-depletion theme relates to the potential negative effects of a higher exposure to UV-B radiation caused by chlorofluorocarbons (CFCs) and halons. These substances are sometimes also regarded as greenhouse gases, but the evidence is mixed. Table 4 expresses the relative contribution of each greenhouse gas in CO_2-equivalents. The conversion factors for N_2O and CH_4 respectively are 309.315 and 20.996. CFCs and halons are expressed in CFC11-equivalents. The resulting aggregated theme-indicators for the greenhouse effect and ozone layer depletion reflect the contribution of Dutch residents to these global environmental problems.

The themes 'acidification', 'eutrophication' and 'waste' relate to internal environmental problems that are caused by the accumulation of pollution on Dutch territory. The acidification theme relates to the damage caused by the deposition of nitrogen oxides (NO_x), sulphur oxides (SO_2) and ammonia (NH_3) in soil and surface water. The eutrophication theme relates to the problem of accumulating nitrogen (N) and phosphorus (P) in soils and subsequently in groundwater and surface water. Acidification and eutrophication are serious threats, for example they endanger ecosystems and the quality of drinking water. The accumulation of waste is a serious environmental problem as well. This theme is restricted to waste consisting of products that have lost their economic use. This kind of waste can be measured in kilograms. Acidification is expressed in acid-equivalents by applying the conversion factors 0.217, 0.313 and 0.588 to NO_x, SO_2 and NH_3, respectively. Nutrient-equivalents, which are assumed to equal 10 kg P or 1 kg N, are taken as the common unit to calculate the eutrophication indicator. The composite theme-indicators for acidification, eutrophication and waste in table 4 are estimates of the accumulation of the relevant substan-

Table 4. Environmental theme indicators, 1997.

	Greenhouse effect (CO$_2$-equivalents)	Ozone layer depletion (CFC11-equivalents)	Acidifi-Cation (acid-equivalents)	Eutrophi-cation (nutrient-equivalents)	Waste (mln kg)	Change in natural resources (petajoules)
CO_2	201020					
$N_2O * 309.315$	22580					
$CH_4 * 20.996$	23180					
	246780					
CFCs and Halons		**931**				
$NO_X * 0.217$			23			
$SO_2 * 0.313$			30			
$NH_3 * 0.588$			103			
			157			
$P * 10$				775		
N				738		
				1512		
Waste					**10710**	
Natural gas						823
Crude oil						162
						985

ces in the natural environment of the Netherlands. The theme ‘change in natural resources’ points to the interdependence of economic activities and the depletion of natural resources. Table 4 shows for natural gas and crude oil the balance of extraction and all other changes in proven reserves in petajoules. The summary theme-indicator estimates the net change in the combined proven oil and gas reserves during the reference year.

3. The NAMEA and policy analyses

The NAMEA is an extension of the SNA that shares a number of key characteristics with the input-output model developed by Leontief (1970). Input-output analysis is a powerful tool for the study of relationships between the economic and environmental variables in the NAMEA. As will be shown below, it is particularly useful as a decomposition methodology. Decomposition is typically helpful in detecting the major driving forces of the periodic changes in the environmental performance of an economy.

3a. Environmental-economic profiles

The respective contributions to the environmental theme-indicators by the consumer's emissions, subdivided by purpose, and the producer's emissions, subdivided by sector, may be straightforwardly compared on the basis of the figures in tables 1, 2 and 4. Next, these pollution shares may be compared to the economic data from the NAM-part of the NAMEA, for example to the corresponding shares in total consumption outlays or value added. This provides an environmental-economic profile, which depicts the environmental and economic role played by the various consumer and producer activities during a year.

With NAMEA-based time series, environmental-economic profiles over time may be constructed. These time profiles may for example address the question how economic change influences pollution patterns. In a times-series analysis on the basis of NAMEA, De Haan (2001) applies an input-output model to decompose the annual change in pollution into changes due to: final demand volume, the structure of production and demand, and eco-efficiency (pollution per unit of output). His results are presented in figures 1-3. The bold lines show pollution rates – the percentage changes in the level of pollution compared to 1987 levels – as measured by the production-related CO_2- and acid-emissions and solid waste generation using annual data for 1987-1998 (solid waste 1997). The figures also depict the breakdown of the pollution rates among its three components. In all three cases, basically two major forces determined the development of pollution. On the one hand, demand volume strongly triggered pollution rates. On the other hand, pollution rates decreased due to efficiency improvements. The structure effects were less strong and generally led to a decrease in emissions. Overall, CO_2-emissions increased by 20% between

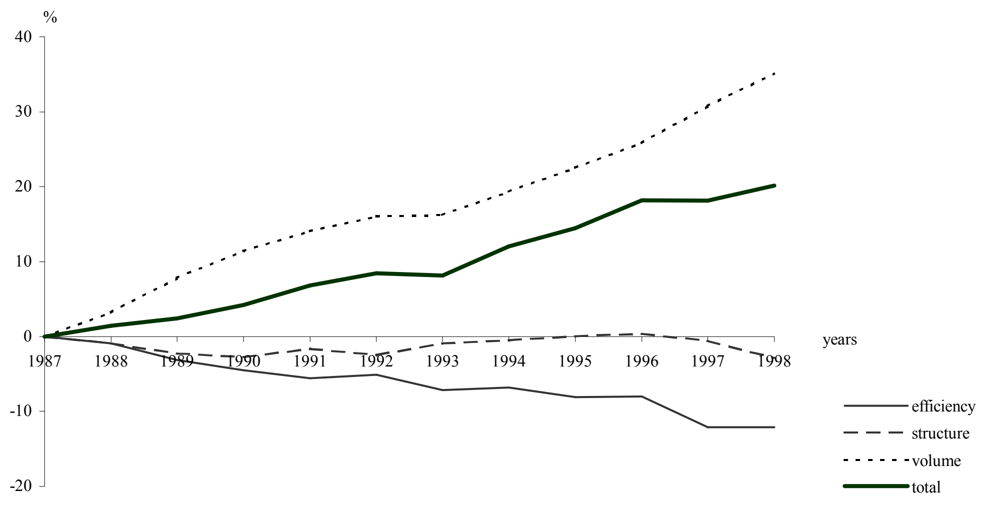

Figure 1. Decomposition of annual changes in production-related CO_2-emissions, the Netherlands, 1987–1998.

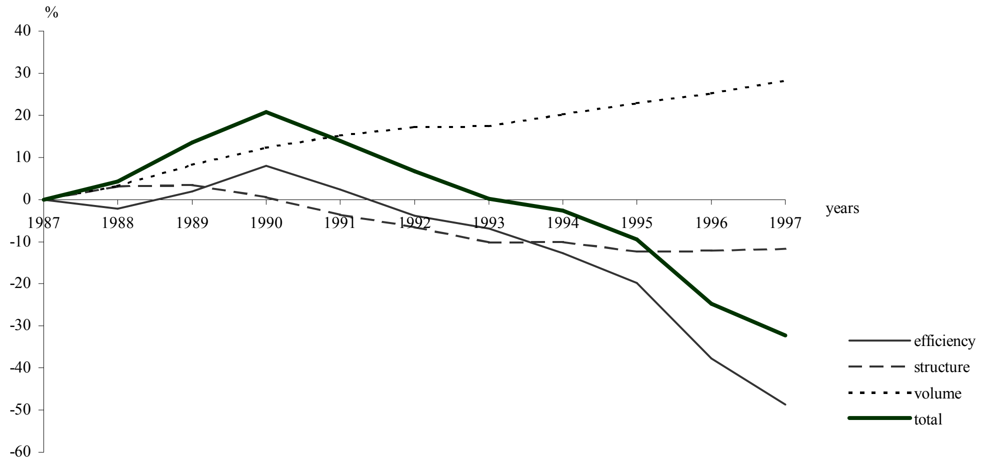

Figure 2. Decomposition of annual changes in production-related solid waste generation, the Netherlands, 1987 – 1997.

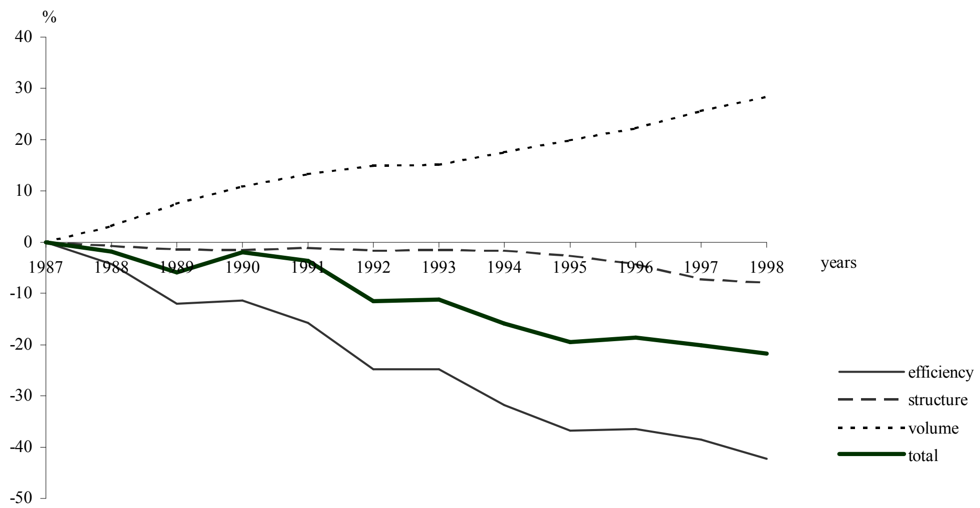

Figure 3. Decomposition of annual changes in production-related acid-emissions, the Netherlands, 1987 – 1998.

1987 and 1998. Production-related pollution in the cases of solid waste and acidification significantly decreased on balance. Further analysis for CO_2 reveals that the macro decomposition pattern generally applies at the industry level as well, though important differences across industries exist. For example, the manufacturing of chemical products and air transport services together are estimated to account for 8 percentage points of the overall efficiency gain of 12%.

3b. Producer and consumer activities

The NAMEA links the activities of producers and consumers directly to the corresponding environmental requirements. The requirements of government activities are registered in relation to government production and not to consumption. Environmental requirements consist of gross emissions minus the residuals that are reabsorbed into the economic sphere by either waste treatment or recycling, and natural resources. Producer activities are classified by industry. This classification is based on the International Standard Industrial Classification (ISIC). Consumer activities are classified by purpose. Table 1 distinguishes between own account transportation and other purposes. A more detailed NAMEA could provide a further breakdown based on a reconciliation of types of consumption expenditure with kinds of household activities. This matching follows the accounting work on household production.

From the link between the environment on the one hand, and producer and consumer activities on the other, environmental-economic performance indicators can be derived. For example, for production eco-productivity indicators can be calculated that measure production per unit of environmental requirement. Table 5 presents eco-productivity indicators related to CO_2 and to the acidification theme. Eco-productivity steadily increased between 1988 and 1998. This means that the environment was used more efficiently in 1998 compared to 1988. The result was a decoupling of economic growth from environmental pressures.

Table 5. Eco-productivity measures for production in the Netherlands.

	1988	1993	1998	1993	1998
				index 1988 = 100	
GDP in market prices (million guilders) in constant (1997) prices	583 399	659 224	750 142	113.0	128.6
Pollution from production					
CO_2 in mln kg	140 620	149 890	166 540	106.6	118.5
Acid-equivalents	350.307	316.798	279.580	90.4	79.8
Eco-productivity					
GDP / CO_2	4.1	4.4	4.5	106.0	108.5
GDP / Acid-equivalents (× 1000)	1.7	2.1	2.7	125.0	161.1

GDP and the emission of CO_2 increased, and the amount of acid decreased during the relevant period. Therefore, decoupling with respect to CO_2 was relative (weak), and with respect to acid absolute (strong). Environmental performance indicators may be derived for individual industries or consumer activities as well. For example, eco-efficiency indicators may highlight the environmental efficiency or inefficiency of specific household activities.

3c. International trade

In section 2a we noted that the figures for the emission by residents, which are reported in table 1, are important for assigning the responsibility of pollution to particular countries. This point of view means that the activities of resident producers and consumers, which were addressed in the previous section, are held responsible for the pollution. Alternatively, the responsibility could be assigned to final domestic demand categories. This approach is followed by De Haan (2002). Final domestic demand will be labelled conveniently domestic consumption, but investment is included as well. Part of domestic consumption consists of goods and services from abroad. In this alternative view then, the pollution caused by the production of these import goods in foreign countries should no longer be regarded as these foreign countries' responsibility. Instead, the importing country would be responsible. This means that international trade is viewed as the displacement of environmental requirements: a country's import involves the export of pollution, and vice versa.

The international transfer of environmental burdens by a country can be addressed by considering its environmental balance of trade. This indicator is defined as the pollution imported via the export of goods and services minus the pollution exported via the import of goods and services. The emissions that can be attributed to domestic consumption are subsequently given by deducting the environmental trade balance from the emissions by residents. We call this measure environmental consumption. Table 6 presents the Dutch environmental balance of trade and environmental consumption for the substances contributing to acidification and eutrophication. The calculation of these two indicators makes use of input-output methods to relate pollution flows to product flows. The first row shows the figures for the net emissions by residents, which are taken from table 3. The next three rows reveal that the pollution embodied in exports exceeds the pollution embodied in imports for all substances. This implies that the Netherlands is a net importer of embedded pollutants related to acidification and eutrophication. This can be seen immediately from the positive environmental balance of trade for all substances. A positive balance means that environmental consumption is less than residents' emissions. Put differently, Dutch pollution responsibilities measured by domestic consumption are lower than those measured by the activities of producers and consumers.

Environmental trade balances may also be calculated for separate trade partners. Table 7 presents the acid

Table 6. The environmental balance of trade and environmental consumption, 1997.

	NO_x	SO_2	NH_3	P	N	Acidification	Eutrophication
	1	2	3	4	5	*f*(1-3)	*f*(4-5)
	mln kg					*acid-eq.*	*nutr.-eq.*
(I) Net emissions by residents	701	236	188	78	917	338	1701
(II) Environmental balance of trade:	207	105	65	20	244	117	441
- emissions attributed to export	521	239	181	73	854	295	1585
- emissions attributed to import (-)	313	134	115	53	610	179	1144
(I) – (II) Environmental consumption	494	131	122	59	673	221	1260

Table 7. The environmental balance of trade of the Netherlands for acid pollution, 1997.

	Export	Import	Environmental balance of trade	Composition effect	Trade balance effect
	1	2	3 = 1 – 2 = 3a+ 3b	3a	3b
	acid -eq.				
Belgium and Luxembourg	36.7	24.9	11.8	- 0.6	12.3
Denmark	4.1	4.7	- 0.6	- 2.4	1.8
Germany	80.9	38.8	42.1	15.5	26.6
Finland	2.5	1.7	0.9	0.8	0.1
France	24.5	13.6	10.9	5.8	5.0
Greece	4.4	0.5	3.9	1.9	2.0
Ireland	2.2	2.7	- 0.5	0.2	- 0.7
Italy	19.3	5.7	13.6	8.0	5.5
Japan	5.3	2.3	3.0	4.7	- 1.7
Norway	2.6	2.3	0.3	3.3	- 3.0
Austria	3.0	1.3	1.8	0.5	1.3
Portugal	2.1	1.0	1.1	0.8	0.3
Spain	8.1	3.7	4.4	2.7	1.7
Czech Republic	0.5	0.3	0.2	0.0	0.2
United Kingdom	31.3	17.6	13.7	11.8	1.9
United States of America	12.3	12.8	- 0.5	3.8	- 4.3
Sweden	4.6	3.9	0.7	1.4	- 0.7
Switzerland	5.9	1.9	4.0	2.4	1.6
Other countries	45.0	38.9	6.1	17.3	- 11.2
Total	295.3	178.6	116.7	77.8	38.9

trade balance and table 8 the eutrophication trade balance for the Netherlands with respect to its main trading partners. The first column shows the pollution imported from the countries to which the exports are directed. The second column shows the pollution exported to the countries from which the imports originate. The third column presents net imported pollution from the respective countries. The most important country of origin of net imports of both acid and nutrient pollutants is Germany, followed by the United Kingdom. These two countries account for 36.1% and 11.7% of total net imports of acid pollutants and 48.7% and 19.7% of total net imports of nutrient pollutants, respectively. Italy, France and Belgium/Luxembourg also are relatively important contributors to the positive acidification and eutrophication related environmental trade balance. Columns 3a and 3b, tables 7 and 8, decompose the bilateral environmental trade balances into components due to the composition of trade flows and into components due to the volumes of these export and import flows. These component parts result from an input-output model and respectively are called the composition effect and trade balance effect. The net import of pollutants in the Netherlands is mainly due to the composition effect for those related to acidification and to the trade balance effect for those related to eutrophication. This overall picture, however, does not completely apply to the two most important net exporters of acid and nutrient pollutants to the Netherlands. For Germany the trade balance effect dominates, and for the United Kingdom the com-

Table 8. The environmental balance of trade of the Netherlands for nutrient pollution, 1997.

	Export	Import	Environmental balance of trade	Composition effect	Trade balance effect
	1	2	3 = 1 – 2 = 3a+ 3b	3a	3b
	nutrient -eq.				
Belgium and Luxembourg	183.5	164.9	18.6	- 53.2	71.8
Denmark	24.2	16.4	7.8	- 0.2	8.0
Germany	470.5	255.6	214.9	51.1	163.7
Finland	8.9	7.3	1.6	1.4	0.2
France	152.4	113.9	38.5	2.5	36.0
Greece	32.8	2.5	30.3	16.4	13.9
Ireland	10.8	19.1	- 8.3	- 4.2	- 4.1
Italy	116.1	32.5	83.6	51.1	32.6
Japan	19.5	7.9	11.6	17.5	- 6.0
Norway	7.0	6.6	0.3	8.6	- 8.2
Austria	19.2	7.5	11.7	3.8	7.9
Portugal	10.4	9.1	1.2	- 0.8	2.1
Spain	42.0	25.5	16.5	6.4	10.1
Czech Republic	3.9	1.6	2.2	0.9	1.3
United Kingdom	163.9	76.9	87.0	77.5	9.5
United States of America	37.9	97.6	- 59.7	- 38.2	- 21.5
Sweden	22.9	19.8	3.1	6.8	- 3.6
Switzerland	18.2	7.4	10.8	5.5	5.3
Other countries	241.1	271.9	- 30.8	36.7	- 67.4
Total	1 585.2	1 144.2	441.0	189.5	251.5

position effect, for both kinds of substances. The environmental consumption perspective calls for an alternative representation of the origin and destination of pollutants, which is provided by De Haan (2001). Rearranging terms in table 6, we get: emissions by residents + emissions attributed to import = environmental consumption + emissions attributed to export. This identity allocates the pollution by origin (source) on the left hand side to the destination (purpose) of pollution on the right hand side. These destinations consist of final demand categories. The equation follows the 'supply = demand' identity of the supply and use tables in the national accounts. Table 9 provides the above set-up for CO_2-pollution in 1990 (col. 1) and 1997 (col. 3). Pollution rates – the percentage change in the level of pollution between 1997 and 1990 – are presented in column 6 of the table. The overall CO_2-pollution rate for the Netherlands was 16%. Looking at the separate origins, we see that the pollution in foreign countries by the Dutch import of goods and services showed the highest rate. The share in total CO_2-pollution of this source increased from 33.5% in 1990 to 35.3% in 1997. Producer and consumer activities experienced identical pollution rates, and hence the first activities' contribution to overall CO_2-emissions remained well above the share of the latter activities. Looking at the separate destinations, the imported pollution by the export of goods and ser-

Table 9. Origin and destination of CO_2-pollution, the Netherlands, 1990 – 1997.

	1990	1997 (disregarding the production effect)	1997	Demand effect	Production effect	Total
	1	2	3	4 =(2-1)/1	5 =(3-2)/1	6 =(3-1)/1
	billion kg			*%-change*		
Origin						
Domestic						
Production (direct)	145	171	163	18	-6	12
Consumption (direct)	33	41	37	24	-12	12
Rest of the World						
Import (attributed)	89	116	109	30	-8	23
Total	266	328	309	23	-7	16
Destination						
Domestic						
Consumption (direct + attributed)	115	139	132	20	-6	14
Capital formation (attributed)	26	27	27	3	0	2
Rest of the World						
Export (attributed)	125	162	150	30	-10	21
Total	266	328	309	23	-7	16

vices showed the highest growth rate. Its share in total CO_2-emissions increased by 1.5 percentage points to 48.5% in 1997. The pollution rate of environmental consumption was just below 13%. The rate of its consumption component was significantly higher than its investment component (14% against 2%). This also holds for the respective shares in overall CO_2-emissions.

With input-output analysis, the pollution rates in table 9, column 6, are decomposed into rates due to a demand effect (col. 4) and rates due to a production effect (col. 5). The demand effect captures the effect of a combined change in demand volume and structure. The production effect relates to the effect of a combined change in eco-efficiency and production structure. The second column in table 9 is based on this decomposition exercise by showing the estimated pollution levels in 1997 in the absence of the production effect. The figures in this column are higher than the actual pollution levels for 1997 in column 3. Put differently, the demand effect is positive and the production effect is negative, as can be seen from columns 4 and 5.

4. Conclusion

This paper examines the relevancy of the NAMEA to accounting for sustainable development. The NAMEA extends the SNA with environmental accounts in physical units. The environmental performance indicators, which are derived from this integrated set of economic and environmental accounts, cover important environmental themes. The paper shows that the linked economic and environmental indicators allow monitoring and analyzing a wide range of sustainability issues within one coherent framework. The incorporation into this single accounting system of a SAM, from which social indicators can be derived, provides opportunities for an integral policy analysis of sustainable development.

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