Towards a Global Regionalised Environmentally Extended Input-Output Database, Linked to the Ecological Footprint

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Abstract

This paper seeks to present and receive feedback on the strategy of an EU –funded Integrated Project of various million Euros: EXIOPOL ("A New Environmental Accounting Framework Using Externality Data and Input-Output Tools for Policy Analysis"). This particularly with regard to its part on environmentally extended input output analysis. The project consists of 37 institutes, is lead by FEEM and TNO, and will run between 2006 and 2010. The project has three principal objectives:

(a) synthesise and develop further **estimates of the external costs of key environmental impacts** for Europe;

(b) set up an **environmentally extended (EE) Input-Output (I-O) framework** for the EU-25 in a global context which as many of these estimates as possible are included, allowing the **estimation of environmental impacts (expressed as LCA themes, material requirement indicators, ecological footprints and external costs) of different economic sector activities**, **final consumption activities and resource consumption** for countries in the EU;

(c) apply the results of the external cost estimates and EE I-O analysis for the **analysis of policy questions** of importance, as well as for the **evaluation of the value and impact of past research on external costs on policy-making in the EU**.

Keywords: environmentally extended input-output analysis, EE I-O, ecological footprint, life cycle impact assessment, total material requirement

1 Introduction: the goals of EXIOPOL

The Integrated Project (IP) EXIOPOL (A New Environmental Accounting Framework Using Externality Data and Input-Output Tools for Policy Analysis) has been set up by FEEM and TNO (being co-ordinator and scientific director) under the EU's 6th Framework Program. It has a budget of 5 Mio Euro and runs between December 2006 and 2010, with the following goals:

(a) to synthesise and develop further estimates of the external costs of key environmental impacts for Europe;

(b) to set up an environmentally extended (EE) Input-Output (I-O) framework in which as many of these estimates as possible are included, allowing the estimation of environmental impacts and external costs of different economic sector activities, final consumption activities and resource consumption for countries in the EU;

(c) to apply the results of the external cost estimates and EE I-O analysis for the analysis of policy questions of importance, as well as for the evaluation of the value and impact of past research on external costs on policy-making in the EU.

Where the concepts of external costs calculation and EE I-O are well known, a comprehensive review of external cost methodologies still lacks, and a comprehensive EE I-O database for the EU25 is absent. The IP creates hence a new, operational toolbox supportive to a great variety of EU policy fields, such as Integrated Product Policy, the Strategy on Natural Resources, the Environmental Technologies Action Plan, Sustainable Consumption and Production, the relation between sustainability and the Lisbon strategy, and impact assessment of related policies in general. Table 1.1 reviews the participants in the project. This paper particularly will present the strategic approach to the EE I-O part of the project, in order to get feedback from the Ecological Footprinting community (FEEM&TNO, 2006).

2 Advances with regard to the State of the Art

The core goal of EXIOPOL is to support cost-effectiveness and cost-benefit analysis of technologies, policies, and standard setting, at the micro, macro and meso level. This requires the coverage of a broad range of impacts and assessment of external costs. To see the IP in this context we present the toolbox that currently is in use or ideally should be used for such assessments, and indicate the main gaps in it. This then gives the rationale on which areas our project has to focus. For this purpose, we refer to the matrix in Table 2.1. Cost-benefit analysis and cost-effectiveness analysis require insights in the following factors:

Table 1.1: Participants in the IP EXIOPOL (status: August 2006. Partners primarily involved in EE I-O marked with *)[1]

Participant. Number	Participant name	Participant short name	Country
1	Fondazione Eni Enrico Mattei	FEEM	IT
2	The Netherlands Organisation For Applied Scientific Research*	TNO	NL
3	University of Bath	UBATH	UK
4	Leiden University, Institute of Environmental Sciences*	UL-CML	NL
5	Joint Research Centre, Institute for Prospective Technological Studies*	JRC-IPTS	ES
6	Wuppertal Institute for Climate, Environment and Energy*	WI	DE
7	National Environmental Research Institute	NERI	DK
8	Forest Technology Centre of Catalonia	CTFC	ES
9	Univerzita Karlova v Praze, Charles University Environment Center	CUEC	CZ
10	Queen's University Belfast	QUB	UK
11	Universitaet Stuttgart, Institute of Energy Economics and the Rational Use of Energy	USTUTT-IER	DE
12	Norwegian University of Science and Technology (including RPI)*	NTNU	NO
13	Nachhaltigkeitsforschungs und -Kommunikations Gmbh*	SERI	AT
14	University of Parma	UNIPR	IT
15	Ecologic Institut für Internationale und Europäische Umweltpolitik	ECOLOGIC	DE
16	University College of London	UCL	UK
17	Association pour la Recherche et le Développement des Méthodes et Processus Industriel, Ecole Nationale Supérieure de Mines	ARMINES	FR
18	Institute of Occupational Medicine	IOM	UK
19	Sweco Grøner As	SWECO	NO
20	Wageningen University	WU	NL
21	Finnish Environment Institute	SYKE	FI
22	Vrije Universiteit Amsterdam, Institute For Environmental Studies	VUA-IVM	NL
23	Chinese Academy of Social Sciences	CASS	CHN
24	European Forest Institute	EFI	FI
25	University of Padova	UNIPD	IT
27	University of Delhi, Institute of Economic Growth	UDELHI-IEG	IN
28	Institute for European Environmental Policy	IEEP	UK
29	Norvegian Institute for Water Research	NIVA	NO
30	Centre for European Economic Research	ZEW	DE
31	Warsaw University, Warsaw Ecological Economics Center	UW-WEEC	PL
32	Clean Air Action Group	CAAG	HU
33	Gesellschaft fuer Wirtschaftliche Strukturforschung	GWS	DE
34	Société pour la Promotion Internationale des Industries Aromatiques	IAP-SENTIC	FR
35	Swedish University of Agricultural Sciences	SLU	SE
36	Flemish Institute for Technological Research	VITO	BE
37	Rijksuniversiteit Groningen*	RUG	NL

[1] The project is being expanded with various national statistical bureaus. Furthermore, an advisory board is set up with other relevant actors, most notably EEA, EUROSTAT, and other bodies like OECD and the World Bank

Table 2.1: Tools needed for analysis of cost-effectiveness and costs/benefit assessment of sustainability options at micro, meso and macro level

Level	**Example**	**Tools for direct cost assessment**	**Tools for impact assessment**	**Tools for benefit assessment[2]**	**Gaps in toolbox filled in this project**
Micro	Company level (e.g. technology choice), household level (e.g. consumption decisions)	Life cycle costing	Life cycle assessment, site specific tools like EIA or RA	External costs, local	- *Externalities:* for many pressures and endpoints external costs are still lacking, there is a variety of conceptual questions still to be solved, and cost data for ready use in meso- and macro accounting frameworks are not available. - *IO and EE I-O*: comprehensive, detailed, uniform and open-source IOTs with environmental extensions for the EU25, and with suitable trade links with the RoW are absent. Such a comprehensive EE I-O database can also support LCA and LCC calculations by providing the system context which allows the estimation of impacts of truncated processes entailed by LCA approaches[3].
Meso	Sector or product group level (e.g. sector standard, tax, or ban)	IO, in combination with scenario tools (e.g. CGE)	EE I-O, in combination with scenario tools (e.g. CGE)	External costs, sectoral average	
Macro	Societal level (as per sector level)	IO, in combination with scenario tools (e.g. CGE)	EE I-O, in combination with scenario tools (e.g. CGE)	External costs, country average	

Note: EIA: Environmental Impact Analysis. LCA: Life Cycle Assessment. LCC: Life Cycle Costing. IOTs: Input-Output Tables. RA: Risk assessment

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[2] Note: we assume here that direct benefits can be included easily in direct (net) costs assessments, so that in here we in fact we have to focus on benefits in terms of the reduction of external costs.

[3] As well known from literature, LCAs try to follow the full supply chain to the final functionality delivered, but due to the networked character of any economy at some point seemingly unimportant supply chains are 'cut off' and neglected in further analysis. It has been shown that the cumulative effects of such cut offs can be up to 50% of the total impact of a product.

a) Calculation of the (net) costs that implementation of a technology, standard or policy will imply.

b) Calculation of the reduction of environmental impacts related to this implementation. The quotient of impact reduction and net costs indicates the cost-effectiveness of the measure.

c) Calculation of the (reduction of) external costs by reduction of impacts related to this measure. Such a reduction of external costs, and (net) investment that a measure requires, allow assessing the true societal costs and benefits.

Sustainability measures can be taken at a micro (e.g. company), meso (e.g. sector) and macro (e.g. country or multi-country) level. And conversely, measures taken at one of these levels can have contrary 'ripple effects' or spillovers at another level. The toolbox needs to be adequately filled for each level, but maybe even more importantly, must be able to create linkages between these levels. The table shows that the main gaps in the toolbox cluster around two issues:

a) The (market) costs and direct (market) benefits of proposed sustainability policies, technologies and standards usually can be calculated rather straightforwardly. This is not true, however, for the indirect, non-market costs or externalities. From previous research it is clear that there are still important gaps in the assessments of external costs, which need to be filled.

b) Implications of measures at meso- and macro level, but also the 'ripple effect' of measures taken at micro level, can only be assessed properly when making use of a framework that covers all relations in the economic system including environmental effects, which only can be provided by environmentally extended input-output tables (EE I-O tables). Such tables are currently simply non-existent for the EU25.

It is particularly the integration and linkage of external cost data with the (EE) I-O tables that provides additional power to the toolbox. This link can be easily provided by expressing external costs in (time and place-independent) cost factors per kg emitted substance, which is the data provided via EE I-O tables. This framework then also allows calculating spillovers between sectors: the I-O table will allow calculating how a change in activity level in one sector may induce changes in activity levels in other sectors, and hence related emissions, external costs, etc .

3 The EE I-O data situation today

To date, the integrated IO table for the EU are not available, let alone the one that integrates environmental extensions and external costs. On the basis of the obligations in the European System of Accounts 1995 (ESA95; EC, 1996), individual EU member states report to Eurostat economic supply-use and IO tables. On a voluntary basis, individual member states report National Account Matrices including Environmental Accounts (NAMEAs) with some 10-15 emissions to air (Eurostat, 2005) All this material is available at a 60 sector resolution only. Various studies including EIPRO (Tukker et al., 2006, Weidema et al., 2005) showed that a much higher resolution of at least 100-150 sectors or more is essential for allocating sustainability impacts in a meaningful way to sectors, products, etc. Furthermore, the ESA95 I-O country tables are not linked via trade to a full table for the EU25. For other countries in the world, detailed I-O tables are available covering a significant part of the global economy (e.g. the US, Japan), but also these tend to be for single countries only and usually have no official links to environmental extensions[4]. The Global Trade Analysis Project (GTAP) gives an regionalised I-O table for the world economy that discerns a fair amount of sectors and regions, and links such data also to energy use, but a problem here is transparency of data.

The EE I-O work in EXIOPOL, roughly half the size of the full project, seeks to solve the problem that a lot of partial data on I-O and environmental extensions is available in Europe, but not integrated into an EE I-O table. It is an explicit goal of the project that the database should not stay in ownership of the developers, but is handed over for structural maintenance and use to one of the relevant Commission's services (DG JRC IPTS, the European Environment Agency, and EUROSTAT). How to organize the heritage of EXIOPOL is part of the project, but this ambition is realistic: DG JRC/IPTS has expressed it willingness to do so in due time. The project aims hence at filling an essential gap in the current toolbox of environmental (and economic) accounting at the Commission's services. This need has been recently emphasised by the Renewed Strategy for Sustainable Development adopted by the Council in June 2006. The project's aim is really to leapfrog: it would give the EU a full-fledged, detailed, transparent, public, official global EE I-O database with externalities, allowing for numerous types of analyses for policy support.

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[4] Individual research groups sometimes combine I-O data with environmental data sources, such as in the US. Japan has developed with a number of other countries bilateral I-O tables that include trade.

4 The approach chosen in the project to improve the EE I-O data situation

4.1 Introduction

The EE I-O work in EXIOPOL has as main goal to develop an operational and detailed EU-25 input-output table with environmental extensions. This is basically an economic input-output table to which per sector discerned information about emissions and resource use is added. The database that will be developed will include external costs data calculated in other parts of EXIOPOL as well. The EE I-O table for the EU25 will be embedded in a global context. This is essential to be able to take pollution and externalities embedded in imports to the EU25 into account (Peters et al., 2006; Nijdam and Wilting, 2003), but also to be able to analyse the effects of sustainability measures taken in Europe on the economic competitiveness of the EU25. The EE I-O table will also be organised in such a way that it can:

- support analyses at micro-level, such as cost-benefit analysis (CBA) and LCA, via so-called hybrid LCA or EE I-O-LCA[5]; thus both improving this micro analysis and linking it to the meso and macro level
- support scenario-analysis for analysis of impacts of sustainability options at meso- and macro level. Such scenario analyses can be done in a variety of ways. One option is to 'force' exogenously a technology-, emission- or demand scenario on the EE I-O table. Another option is to endogenize economic developments. For this purpose, the EE I-O table developed will be linked to existing CGE models in use with the EU and macroeconometric models. Furthermore, an alternative model (the World Trade Model; Duchin, 2004) will be expanded in this project to create a third approach to scenario analysis[6].

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[5] As shown by e.g. Lenzen (2000) the truncation in the process LCA approach may lead to the situation that several dozen percent of the life cycle impact of a product is neglected. Estimation of economy-wide environmental impacts of such truncated flows with EE I-O can improve LCA results tremendously. See also Heijungs and Suh (2002)

[6] Most CGE models tend to be best suited to forecast rather 'smooth', incremental changes of the economic structure endogenizing a number of economic relations in the model, but are less apt to deal with scenarios

Our EE I-O table covers emissions and resource uses per sector per country covered (e.g. per individual EU25 member state). Meso- and macro tools like EE I-O tables usually do not have further geographical specification[7].

4.2 Overall approach and strategic choices made

Developing the indicated EE I-O table is an ambitious task. There are four major issues at stake that need attention (see Figure 4.1 for the relation between WPs)

- First, for the countries included in the table individual IO tables have to be gathered, uniformed, and for the EU25 countries enhanced in sector detail.
- Second, for the countries included in the table various dozens of environmental extensions per sector have to be gathered.
- Third, the country tables have to be linked via trade data. This is far from trivial and actually one of the crucial issues to be solved in Cluster III[8].
- Fourth, all data have to be embedded in a user-friendly general purpose database system, that can support e.g. LCA, direct scenario analysis, CGE models, etc.

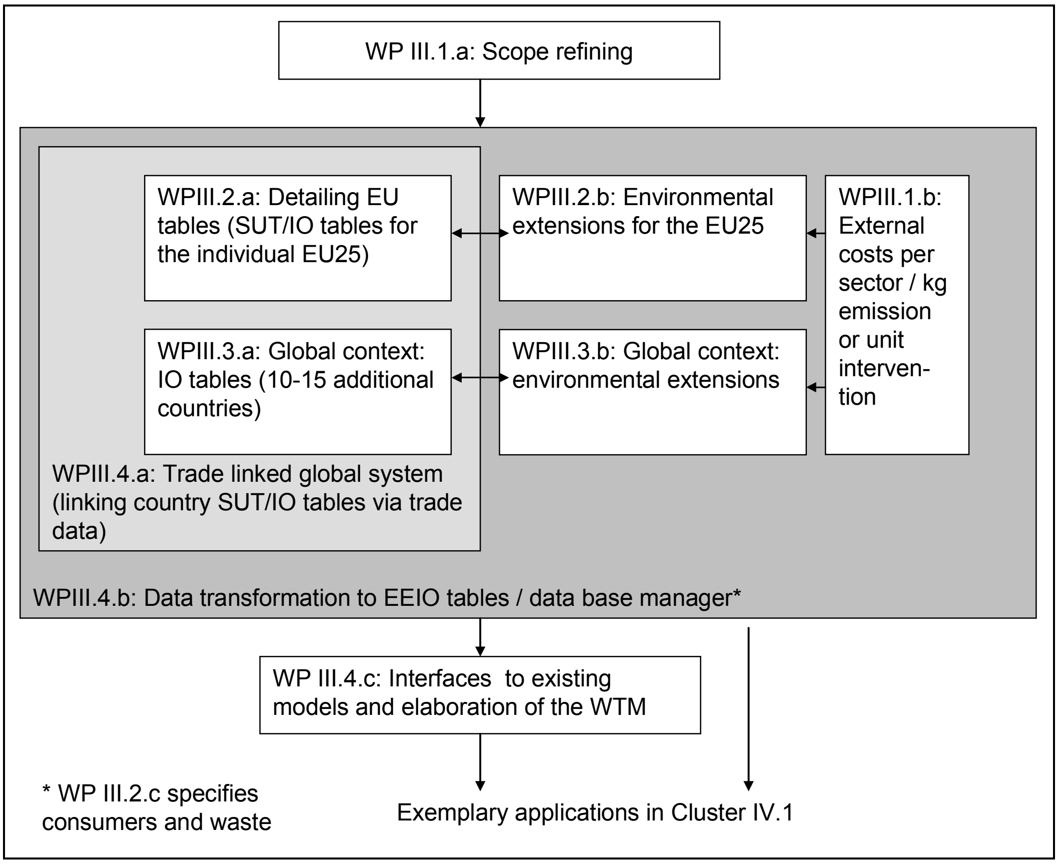
In doing this work, the following strategic choices have been made:

involving radical, fundamental changes in the underlying economic structure. The WTM allows for imposing exogenously rather radical policy scenarios, while calculating the optimal use of factors/resources globally at a given final demand. This makes the WTM an interesting tool for analysing 'what-if' scenarios that aim to realise radical changes to sustainability.

[7] In the sense that very specific locations can be taken into account in emission-effect modelling. There are of course regionalised IO tables at sub-national level in use, but beside the fact that we do not develop these, they are still not sufficiently detailed to allow for local effect modelling nor local externality calculations. For instance, where in the FP6 project TransTools input-output tables from GTAP are regionalized on NUTS-2 level for a CGE analysis (leading to a spatial CGE model called CGEurope), this for instance still is insufficient to do precise externality calculations for the impacts of, say, transport within cities.

[8] Trade databases like COMTRADE (UN) and STAN (OECD) usually only give bilateral trade data for countries, but do not specify the sectors of import and export. Furthermore, there is a host of trivial and less trivial reasons why total import data and total export data that in theory should be identical, do not match. See for instance the thesis of van der Linden (1999), guided by Oosterhaven of RUG, for solutions of these problems.

Figure 4.1: Relations between main Work Packages in the EE I-O part of EXIOPOL



1. To take officially collected statistics by Eurostat as a starting point. This implies using for the EU25 the ESA95 SUT and IO tables, the NAMEAs air, and resource uses.
2. To use open sources only, and produce a database for the public domain
3. To give priority on building the database, since that is the unique added value of our project, rather than to give priority to model building[9];
4. To concentrate work in relatively large WPs and on a limited number of 9-10 partners, in order to maximize coherence and minimize communication problems[10].

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[9] Particularly developing another CGE model would have much less added value, given the many already available. Our strategy is to ensure the database can be easily used in combination with existing models, particularly CEPAM-GEM-E3 as in use at IPTS, probably GINFORS, etc.

[10] As essential issue, since all data finally have to be structured into a similar format, which implies that a high degree of co-ordination of work in the different WPs is essential.

4.3 Gathering and detailing I-O data from the EU25 and other relevant countries

4.3.1 Main approach

The first two principles mentioned in section 4.2 imply that at this stage, the intention of the project is to build an global regionalised EE I-O table, centred around EU25, from officially reported data. The alternative was to use GTAP, a global trade-linked IO table that discerns over 80 regions and about 60 sectors. The main drawback is that GTAP is commercial and not public, and as a result of this, to some extent intransparent. In order to create an operational EU25 table with Eurostat data, inevitably this project has to solve the problem of linking IO tables of 25 countries via trade. By adding another 10-15 strategically chosen countries (for which the OECD mostly publishes IO tables in a common format), coverage of over 80% of the global GNP and environmental impacts is possible. We also considered using the database underlying the GINFORS model used by SERI and GWS in the FP5 MOSUS project. SERI and GWS agreed to provide these data as an open source package. The drawback is that the level of detail in particularly the trade links is very limited (25 products). We hence chose to see the use of GTAP and GINFORS data as fall-back positions, and prefer to work out a better, transparent trade-linked table ourselves. This strategic choice is of course subject to evaluation in the Scoping WP for the EE I-O work.

4.3.2 Sector classification

A key point in the project is to apply a sound sector classification, in relation to choices made with regard to the level of detail in sectors pursued (see next section). The data in the EE I-O database first refer to all SAM categories, including transfer payments and investments. Next, they refer to all environmental interventions including resources extractions, linked to sectors and final consumption activities, and they refer to all physical flows between these, linked to products flows. The nomenclatures used for quantitative descriptions are available in many variants and often different between applications and regions. All sector classifications will be transformed in the new NACE rev.2 nomenclature and the adjoining revised ISIC nomenclature. Product classifications, come from three domains: IO related (CPC, CPA); trade related (HS, CN) and function related (COICOP; COFOG; COPNI and COPP), all at several levels of resolution and usually with slight adaptations for specific applications, like *COICOP/HICP*. Based on options and restrictions in the data, an optimum level of an "as high as reasonably possible resolution" will be defined. Transformation tables relating all source classifications to the standard classes form the first main element in the data transformation structure.

4.3.3 Creating detail in sectors

Studies like EIPRO (Tukker et al., 2006) have shown that a high level of sector detail is essential for obtaining a proper insight in how environmental pressures and interventions relate to economic activities or clusters of economic activities. This detail is particularly relevant for sectors with a high impact, or sectors related to final consumption activities with a high life cycle impact. At the same time, open sources that structure I-O data in a similar format for a number of countries (most notably the ESA95 supply and use tables for the EU25 member states and the OECD I-O tables for a variety of EU and non-EU countries) typically reach a level of detail of 60 sectors.

The desired detail will be specified in the Scoping WP of the EE I-O work. However, previous studies give insight in which economic activities give the highest environmental impact and in which overall sector the impacts differ significantly in type and magnitude per sub sector[11]. Here, we think that the following additional detail above currently reached in ESA95 is desirable:

a) agriculture and food production (+10-15 sectors),

b) resource extraction (+10 sectors),

c) housing and energy using equipment (+ 10 sectors), and probably some others[12].

Detail will be realised by developing technology transfer assumptions making use of one or more of the following data sets: detailed sector data from SUT/IO tables from EU member states, using

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[11] See e.g. Tukker, A., G. Huppes, S. Suh, R. Heijungs, J. Guinee, A. de Koning, T. Geerken, B. Jansen, M. van Holderbeke and P Nielsen (2005). Environmental Impacts of Products. ESTO/IPTS, Sevilla; Weidema, B.P., A.M. Nielsen, K. Christiansen, G. Norris, P. Notten, S. Suh, and J. Madsen (2005): Prioritisation within the integrated product policy. 2.-0 LCA Consultants for Danish EPA, Copenhagen, Denmark; Journal of Industrial Ecology 10:3 (forthcoming), special issue on Environmental Product Policy. Note that this level of detail of about 100 sectors is a minimum ambition; with the right technology transfer assumptions higher detail is possible.

[12] But, for instance, not transport. Transport causes a high impact, but the distinction between car, public, truck, air and water transport as already available in most I-O tables is sufficient.

detailed sector statistics from e.g. the IEA and FAO, and others. Risks will be managed by testing the envisaged procedure on a set of 2 EU countries by Month 12 (to be used in the pilot 3 country trade linked system). Economic data for all EU25 countries will have been inventoried by Month 18. A minor part of the budget will be reserved for adjustments deemed necessary after this date, when all data are integrated.

4.4 Gathering environmental extensions from the EU25 and other relevant countries

In an EE I-O table, for each sector the environmental interventions have to be listed. These include the use primary resources (including land) and emissions. As is well known from Life cycle assessment of products, there can be hundreds of such interventions and listing or analysing these is usually not a suitable input for policy making processes. Usually, more aggregated indicators (so-called impact categories) for environmental pressure are used. The project aims to inventory at least those emissions and resource uses that allow expressing environmental pressures in the following, widely used, impact categories:

- various environmental themes usually applied in Life Cycle Impact Assessment, most notably GWP, ODP, POCP, acidification, eutrophication, and where possible ecotoxicity and human toxicity (methodology available, see e.g. Guinée et al., 2002, and the explanation below)
- Total Material Requirement (methodology available, see Eurostat, 2001)
- Ecological footprint (methodology available, see Wackernagel et al., 2005)
- External costs (part available, part developed in Cluster II; to be transformed for use with EE I-O in a specific WP)[13].

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[13] In principle, external costs can be expressed per kg emission of a substance, in relation to the full set of end-points that is affected by this substance. Hence, with the emissions in an EEIO table known, calculating full external costs would be a matter of multiplying total emissions with such unit external costs per kg emission. But as some additional complications have to be solved due to the top-down/rather time- and location independent character of EEIO and the bottom-up/location specific approach used until now in the calculation of externalities. The Life Cycle Impact Assessment (LCIA) methodology has also struggled with the question to what extent LCIA could be made more location specific, and the final solution may be

Table 4.3 shows which environmental extensions (or 'pressures') have to be gathered to be able to calculate the impact indicators mentioned above. Obviously, good use will be made from existing databases and ongoing work, most notably the work on the NAMEA Air and material use of Wuppertal Institute and partners for EUROSTAT, the resource use database of SERI developed in the MOSUS project, and all kind of international emission databases in which TNO was often involved as a partner..

Table 4.1: Environmental pressures and impacts covered in EXIOPOL[14]

Pressures ('inventory of interventions' or 'environmental extensions')		**Impacts / Impact indicators**
Emissions (air, water, soil)	*Key Data sources*	
• GWP substances (CO2, CH4, etc.) • Ozone depleting substances (HCFCs, etc.)	EU25: Eurostat NAMEA-air project RoW: UNFCCC Annex 1`parties ; EDGAR/TEAM other countries	LCA impact categories With the interventions listed left the following themes from LCA can be calculated (e.g. using the method of Guinée et al., 2002): • GWP • ODP • POCP • Acidification • Eutrophication Ecological footprint (EF) Wackernagel et al. (2005) describe a method that allows calculating the EF on the basis of GWP emissions, land use, and the use of specific biotic resources, which are all inventoried. Total material consumption (TMC/MFA) Wuppertal institute (Eurostat, 2001) developed a method that uses the items listed under 'input of primary resources' to calculate indicators such as the Total Material Consumption External costs The list of emissions left covers all emissions for which past research and EXIOPOL have calculated impacts in terms of external costs. WP III.1.b will transform such data in external costs per kg emission.
• Acidifying substances (SO2, NOx, NH3) • POCP forming substances (NMVOC)	EU25: Eurostat NAMEA-air project RoW: LRTAP convention for UN-ECE members ; TEAM/ EDGAR for other countries	
• Eutrophying emissions (NH3, PO4, BOD) • Toxic pollutants (mainly energy related: (As, Cd, Cr, Pb, Ni, formaldehyde) • Toxic pollutants (mainly transport related: BaP, benzene, 1,3 butadiene, diesel particles, PM10) • Pesticides	EU25: LRTAP convention, where incomplete from TEAM RoW: LRTAP convention for UN-ECE members ; TEAM/EDGAR for other countries	
Input of primary resources		
• Primary energy carriers • Other abiotic resources • Biotic resources	EU25: Ongoing Eurostat project and Wuppertal Institute and SERI/MOSUS database RoW: SERI/MOSUS database, IEA, UNSD, FAO, WMC, etc.	
• Land use	EU25: FAOSTAT, CORINE landcover, others RoW: FAOSTAT, CORINE landcover, LUCC, NASA	

to use impact categories like Disability Adjusted Life Years Lost (DALYs – Human health) or Potentially Disappeared Fractions (PDFs – Ecosystem health/biodiversity) calculated with LCIA, in combination with external costs per DALY or unit PDF (e.g. Guinée et al., 2002).

[14] Our work fits as follows in the well-known DPSIR (Driver-pressure-state-impact-response) framework. Economic activities (reflected by the IO table) form the Drivers. The environmental extensions (emissions and primary resource use per sector) form the Pressures. Via the Impact assessment methods listed left, indicators for State and particularly Impact are calculated. Potential Responses are part of the exemplary policy scenario analyses in a policy application part of the project

4.5 Linking I-O tables via trade and linking I-O tables to models

One WP has the central objective to link the tables for EU countries and the tables of other countries/world regions developed in the other WPs via trade. This work is demanding in terms of data needs and will have to encounter a variety of practical problems, such as:

- Differences in classification systems of trade data and the SUT/IOT data at country level
- The origin of the sector from which is imported and the destination of the sector to which is exported is usually not registered in trade databases.
- At global level total imports and exports per commodity (in theory identical) usually do not match, a.o. since exports and imports are expressed in different price types

As discussed before, we made strategic choice to create a transparent, open and detailed IO/trade database, rather than use commercial databases or databases with a rather low resolution[15]. This WP will be set up as a Ph.D. trajectory at RU Groningen, which has ample previous experience in this type of work[16]. As in the former WPs, the risks of the WP will be managed by testing the detailed structure that has been decided upon in the scoping WP III.1.a on a trade linked system for 3 countries.

Ultimate use of the newly constructed tables is in modelling for policy support and more general decision support, often linking to models with broader behavioural mechanisms like CEPAM-GEM-E3, NEMESIS and the World Trade Model. The interfaces to these models will be constructed in a most open way for such further applications. Special attention will be paid to dynamic aspects. Within the project a set of data will be constructed for one year only. However, in due time, after the project, time series can be constructed and in a shorter time frame these may be based on partial time series as in NAMEAs. Also, in a smaller part of the project dealing with policy applications, some exemplary scenarios will be constructed to deal with dynamic changes

[15] As discussed this concerns GTAP and the database underlying the GINFORS model, which we see as fall-back options for our project.

[16] Most notably the recent PhD of Jan van der Linden from 1999, RU Groningen, that applied on a smaller set of EU member states the procedure we propose for the around 40 countries/regions we probably will discern. Van der Linden basically divided the total exports of a product from all rest of world countries to one country to sectors in the importing countries using import statistics. He overcame the various trivial but difficult to reconcile different approaches in the reports of import and exports by applying a RAS procedure. An alternative approach is used by GTAP, who try to assess the reliability of countries in reporting trade data and use this as a criterion which data to use.

in technologies, consumption, and trade. So the interface to broader modelling, the last workpackage in EE I-O cluster (see figure 4.1), will reckon with three levels of dynamics, each with their own requirements: as time series, in scenarios, and as endogenized technological change.

5 Discussion and conclusion: key choices for discussion

The EE I-O database we envisage to develop will be an extremely powerful support for a great variety of EU environmental and general economic policies. It will allow for analysis, monitoring and improvement assessment of issues such as the total environmental impacts and external costs per industry sector, per final consumption activity, per final product group, related to imports to and exports from the EU25 and per resource used (e.g. Femia and Moll, 2005; Tukker et al., 2005; Tukker and Huppes, 2005; de Haan, 2004; Suh, 2006; Giljum et al, 2006). By splitting up the total consumption into consumption patterns of different target groups, analysis of the life cycle impacts and external costs per target group, life style pattern, etc. becomes possible (Hertwich, 2005). The tool will allow for a structural path analysis and contribution analysis (i.e. which sectors or processes contribute to what extent to impacts or external costs related to products or resources used, and if these processes are located in the EU or are related to imports)[17]. It will do so in a number of widely used and inspiring indicators: external costs, ecological footprint, and various LCA impact categories.

Where this end point is very attractive, it is also clear that the road towards it is on the one hand complex and on the other hand may provide a number of unique opportunities. The *complexity* lies in our view particularly in aligning I-O tables from different sources, detailing them, and above all linking them via trade. Our strategic choices made – giving priority to the use of official ESA95 data and transparency – imply that we have to start with unlinked, individual country data with all the complexity that this gives. Open for discussion are hence our following points:

[17] We list here applications feasible with the database that we envisage to develop. When other data such as employment numbers per sector and added value are included, socio-economic analysis become possible as well.

a) The strategic points of departure (see section 4)

b) To approach the world economy as a '25 (EU countries) + 15 (Rest of world)' country system, extrapolating the 150 other countries that may form only 20% of the global GNP

c) Our ambition with regard to the level of detail in sectors

d) Other.

The *opportunity* however is also clear. In many individual projects or for many individual research groups working on EE I-O, the subject of modelling imports becomes of clear importance (e.g. Peters and Hertwich, 2006; Nijdam and Wilting, 2003). On an individual basis, they usually have no option but to discern just a few main trade partners and gather specific EE I-O data for these trade partners. EXIOPOL could however grow to a collaborative effort well beyond the project partnership itself, in which various research groups would contribute their own EE I-O data and get a sound 'rest of world' EE I-O database in return. It would maybe add another level of complexity in the project, but to forego even investigating this option of creating the 'EE I-O Wikipedia project' would be a lost chance.

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