PROJECT N. 037033

EXIOPOL

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

Technical report on sources for environmental extensions for EU25 and RoW

Scoping of work packages III.2.b, 2.c and III.3.b

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1 Introduction

1.1 Overview and objectives

The objective of Cluster III is to set up an environmentally extended (EE) Input-Output (I-O) framework for the EU-25 in a global context. This scoping paper provides an overview on the environmental extension part, particularly related to data availability for Europe and RoW.

Section 1.2 gives a brief overview on data demand with regards to environmental extensions followed by some reflections on basic conceptual issues related to allocation of environmental extensions in the overall Input-Output framework (section 1.3). Chapter 2 is subdivided in several groups of environmental extensions, namely: material inputs, land use, water input, energy and air emissions, emissions to water, and waste. Each group is discussed along the following aspects:

a) General presentation of data availability (overview)

b) Pitfalls and problems for use and transformation to EXIOPOL data base

c) Key choices and proposals how to overcome problems

The concluding chapter 3 summarises the key problems and choices the Cluster III team has to tackle with regards to environmental extensions.

1.2 Key demands

This scoping report on environmental extensions is mainly related to the following two work packages within Cluster III of the EXIOPOL project:

- III.2b Environmental Extensions for the EU (Wuppertal Institute)
- III.3.b: Environmental Extensions – the global context (SERI)

It is of further particular relevance for work package

- III.2.c Consumers and Waste

The overall objective of WPIII.2.b and WPIII.3.b and partly WPIII.2.c is to gather and process environmental extension data so as to build up the environmental extensions of the monetary EXIOPOL Input-Output framework. The integration of environmental extensions into the overall EXIOPOL Input-Output framework is dependant on methodological concepts as decided upon in WPIII.1.a (see also following section 1.3).

According to the DoW, the following main environmental extensions are to be considered:

- air emissions,

- material inputs, and
- land use.

We recommend grouping the environmental extensions into two generic categories according to the conventions in the UN System of Integrated Environmental and Economic Accounting – SEEA 2003 (United Nations et al. 2003):

1. Natural resources (physical inputs to the economy): material inputs, land, and water, energy use
2. Residuals (physical outputs out of the economy): air emissions, emissions to water, waste

1.3 Relating environmental extensions to the overall Input-Output framework – conceptual issues

The economy (as statistically portrayed by Input-Output tables) is physically embedded into the environment. Both systems are interconnected via physical flows (also called environmental interventions): material inputs are flowing into the economy (e.g. in form of water or raw materials) and material flows are released from the economy into the environment (e.g. in form of emissions and waste). These physical transactions are to be recorded in such a way that they can be consistently linked to the I-O framework, i.e. economic activities. The physical flows (also called environmental *pressures*) can be further grouped and transformed in so-called environmental *impact* categories (such as e.g. Global Warming Potential) representing and anticipating the actual harm to the environment and human health.

Input-Output Tables are part of the System of National Accounts (SNA; and ESA, the European version), an international standard for macro-economic statistics. In principle, environmental extensions to I-O are to follow the very same definitions and accounting rules as laid down in the SNA and ESA.

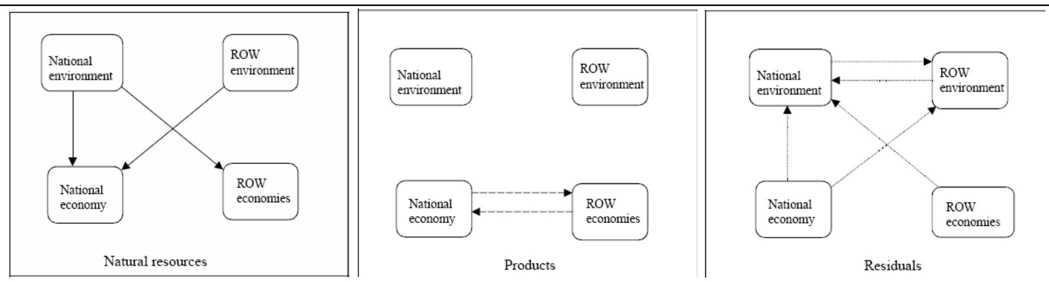
The System of Integrated Environmental and Economic Accounts – SEEA 2003 (United Nations et al. 2003) provides the conceptual foundation for environmental extensions to SNA-based I-O. The SEEA 2003 handbook forms a satellite system of the SNA that comprises several categories of accounts of which three are relevant for the EXIOPOL context:

- *Physical Flow Accounts* (chapter 3 in SEEA 2003) consider purely physical data relating to flows of materials and energy and records them as far as possible according to the accounting structure of the SNA.
- *Hybrid Flow Accounts* (chapter 4 in SEEA 2003) show how flow data in physical and monetary terms can be combined. Emissions accounts for greenhouse gases are an example of the type included in this category.

Asset Accounts (chapter 7 in SEEA 2003) in the SEEA comprises accounts for environmental assets measured in physical and monetary terms. Timber stock accounts showing opening and closing timber balances and the related changes over the course of an accounting period are an example.

Broadly three types of flows can be distinguished (see SEEA 2003, p. 30):

1. *Natural Resources* cover mineral and energy resources, water and biological resources (in addition land is considered in the context of EXIOPOL). Natural resources flow mainly from the national environment into the national economy.
2. *Products* are goods and services produced within the economic sphere and used within it, including flows of goods and services between the national economy and the rest of the world.
3. *Residuals* are the incidental and undesired outputs from the economy which generally have no economic value and may be recycled, stored within the economy or (more usually at present) discharged into the environment.



Source: SEEA 2003, p. 31

Figure 1: Flows between economy and environment

Figure 1 shows how the connection between environment and economy for the 3 flow types. Both, environment and economy, can be distinguished into national and rest of the world.

Input-Output tables constitute a accounting framework to present/record the flows of products. Two types of Input-Output frameworks exist:

- Supply- and Use Tables (SUT)
- Symmetric Input-Output Tables (SIOT)

Flows of natural resources and residuals are subject to environmental extensions (EE). They can be attached to both frameworks, SUT and SIOT. The decision of whether EXIOPOL will use a SUT and/or SIOT framework is still pending and subject to another scoping report. Therefore, both ways of attaching environmental extensions are discussed below.

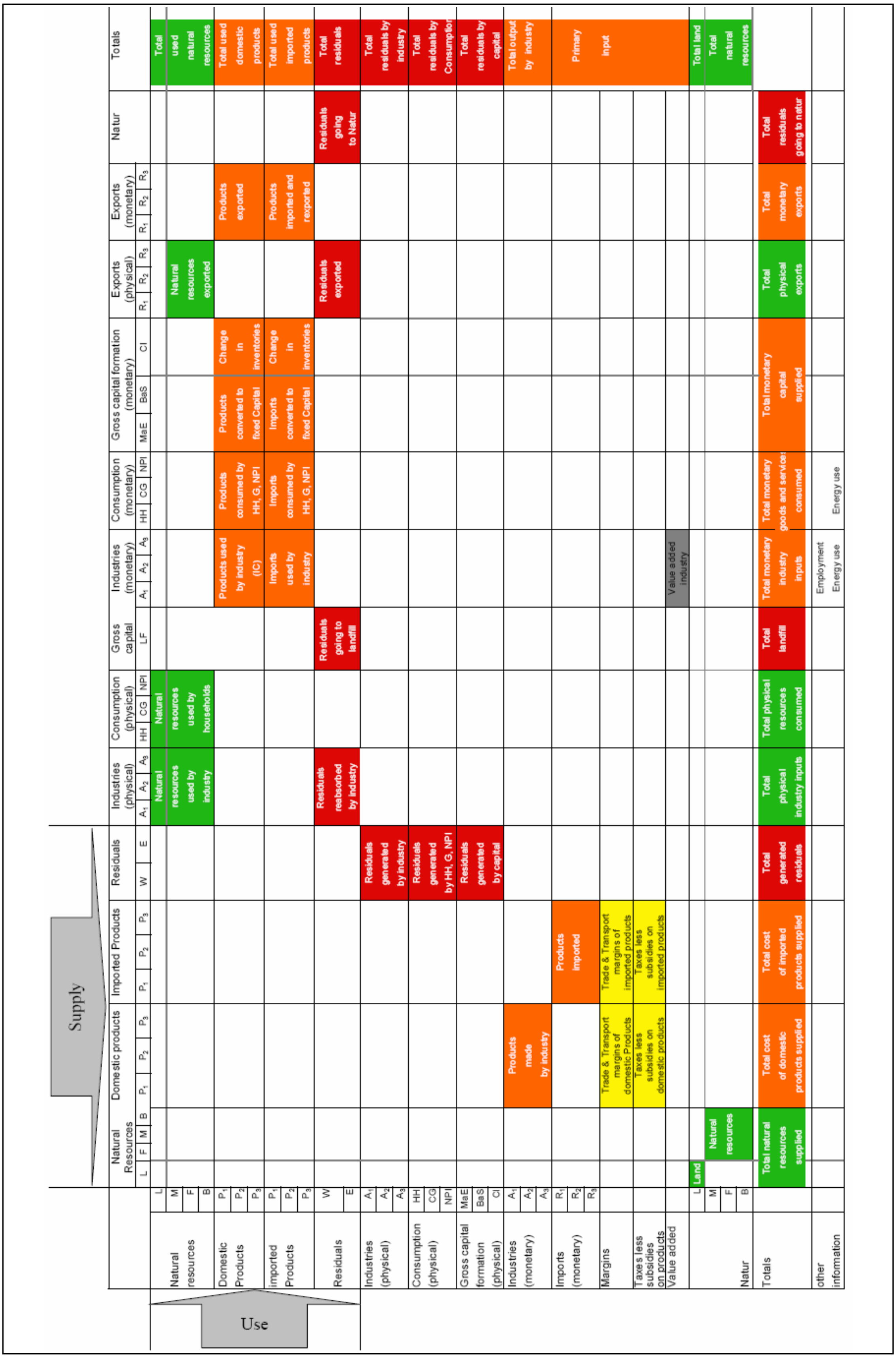


Figure 2: Environmental extensions in a Supply-Use framework (EE-SUT)

It has to be noted, that the SUT framework is a comprehensive mean to arrange data as observed. The SIOT framework is required to perform Leontief-type of analyses. This implies that data arranged in a SUT framework always have to be transformed into a SIOT arrangement e.g. with the help of mathematical transformations.

Figure 2 presents a simplified scheme for the attachment of environmental extensions to a Supply-Use framework – an EE-SUT. The 'use' of natural resources, products and residuals is recorded row-wise in the upper-right part of the scheme. Natural resources are extracted ('used') by production activities (industries) and consumption activities (households, government and non-profit organisations).

Residuals are mainly discharged to nature ('used' by nature). To a certain extent, residuals are also 'used' by economic entities. This applies for residuals which are adsorbed by certain industries (e.g. waste management and recycling) and, residuals i.e. waste, going on controlled landfills (as far the latter are considered being part of the economic sphere).

The 'supply' of natural resources, products and residuals are recorded column-wise in the lower-left part of the EE-SUT scheme (Figure 2).

Natural resources are supplied by nature. Residuals are exerted ('supplied') by several economic entities, namely: industries, consumption activities (including households, governments and non-profit organisations), and fixed capital (e.g. from the stock of buildings, machineries, durable products etc.).

One important feature of this EE-SUT framework is that the row-totals are equal to the column totals. For instance, the total of residuals supplied (column sum) has to equal the total use of residuals (row sum).

The EE-SUT scheme also offers the flexibility to record the supply and use of residuals not by industries but by products. This would require to include a set of columns and rows for physical products (between the items 'imported products' and 'residuals' in Figure 2).

This may become helpful in cases where statistics on environmental extensions are not reported by industries but by production technologies, i.e. associated with certain products. For instance, air emission inventories report data broken down by technologies, independent of where those technologies are applied (i.e. in which industry branches). One example is CO2-emissions from coal fired power plants. The air emission inventory only shows how much CO2-emissions arise from the electricity production in coal fired power plants. It, however, does not give any information with regards to the owner of the coal power plants. It is quite usual that certain manufacturing sites employ their own power plants and produce electricity by their own as a by-product.

Figure 3 shows one possible EE-SIOT attaching environmental extensions to a symmetric Input-Output framework. Here several options exist. The scheme in Figure 3 is a so-called satellite approach. The monetary SIOT remains as it is and the non-monetary environmental extensions are attached in form of separate accounts underneath the monetary accounts. It is also thinkable to merge monetary and physical flows into one symmetric system arriving at so-called hybrid tables.

The satellite accounts of environmental extensions are rather simple. There is an input-matrix of environmental extensions and an output-matrix. Inputs are natural resources and residuals. The output matrix of environmental extensions comprises the several residuals. It is recommended to use negative values for these inputs; at least for the residuals in order to calculate net-residuals (sum of inputs and outputs).

The simplified EE-SIOT scheme in Figure 3 does not consider controlled landfill sites and the natural environment since they are usually not part of the monetary SIOT. As a consequence the total of residual inputs in the EE-satellite does not equal the total of residual outputs.

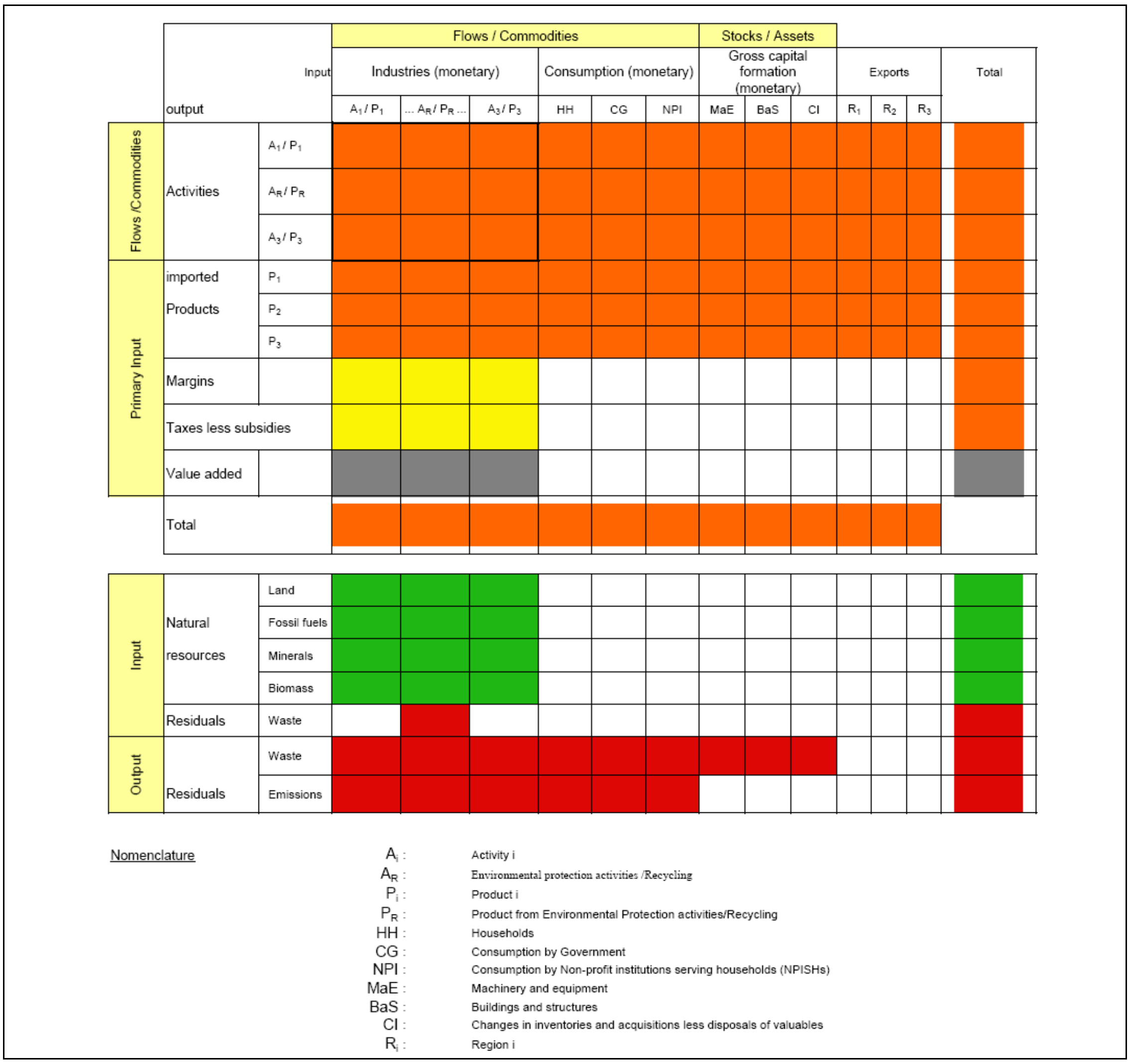


Figure 3: Environmental extensions in a Symmetric Input-Output framework (EE-SIOT)

The natural resource flows entering the economy are linkable to natural stocks as well. The environment can be thought of in natural capital terms as a collection of various types. The SEEA 2003 distinguishes broadly three categories of natural capital: natural resources, land and ecosystem inputs.

Chapter 7 of the SEEA 2003 presents methods to compile physical and monetary asset accounts and how to link stock and flow information.

1.4 Consideration of resource stocks – conceptual issues

The debate on finiteness of global raw material resources and the availability of energy and materials for future economic growth in different world regions has significantly gained in intensiveness in the past few years. In particular, for fossil energy sources, it is discussed, whether or not global extraction of crude oil has already reached or even past its maximum ("peak-oil") (for example, Hirsch et al., 2005).

On the one hand it is argued that continuing high levels of material use in the industrial countries along with rapidly growing demand for raw materials in newly industrialising countries such as China and India will lead to supply shortages on world commodity markets and keep prices at a high level. This trend can be expected despite the fact that capacities for supply of raw materials are currently expanding (AIECE, 2007).

On the other hand, it is argued that resource scarcities are no major problem in the short run (European Commission, 2003), as with ongoing technical progress, higher quantities will be technically exploitable, high prices will increase the number of reserves that can be profitably exploited, resource use will be more efficient, and more material will be recycled, leading to longer lasting reserves (BGR, 2006).

Data on resource stocks (and resource prices) are so far missing in many European and global models. For example, the GINFORS model, a global multi-country, multi-sectoral economy-energy-resource model (Meyer et al., 2007), does not contain information on available stocks of material resources for future extraction. Therefore, in current scenario simulations, growing global demand for raw materials in the future is always met by growing extraction without taking supply-side limitations into account. No repercussions of possible shortages in raw material supply and changes in prices to the economic system can thus be considered in the model simulations (Giljum et al., 2007). The World Trade Model (Duchin 2005; Stromman and Duchin 2006) is a multiregional input-output model that explicitly represents available stocks as potential constraints on production, but its current database incorporates only a limited number of crude estimates to quantify selected stocks. The logic of this model could directly integrate data on stocks of materials designated as strategic as a possible limiting factor for development and growth in the future. It would do so by estimating the increases in their relative prices as scarcity rents rise.

It must be emphasised that (at least in the short term) not the overall size of the resource stock will determine annual extraction rates and resource supply for energy transformation and manufacturing sectors, but rather excavation and refining capacities, which again depend on investments in exploration, mining and processing of natural resources. Therefore, not only data on available resource stocks will be considered in EXIOPOL, but also estimations on likely future mining capacities.

Inclusion of these kinds of data will allow this increasingly important aspect to be better taken into consideration in economic-environmental modelling. This would allow for proper inclusion of feedbacks of resource scarcities and rising prices for energy and raw materials to the economic system and would enable running scenarios, which simulate supply-side restrictions or even shock scenarios, for example, in the light of the current discussion on "peak oil" (see also Kerschner and Hubacek, 2007).

In addition to materials, it is also interesting to consider specific stock data with regard to land use. While the overall land area of a country is fixed, transformations between different types of land use are continuously taking place. In many industrialised countries, agricultural zones and, to a lesser extent, forests and semi-natural and natural areas are disappearing due to the expansion of artificial surfaces and built-up areas (for example, EEA, 2005).

For the simulation of scenarios on changes in diet (e.g. changes in meat consumption) and agriculture (e.g. increasing production of biofuels), it is necessary to collect information on the potential agricultural areas, which could be used as rain-fed or irrigated production area in the future. Also these aspects regarding the transformation of different types of land use will be considered in the work on natural resource stocks in EXIOPOL.

1.4.1 Resource stocks in the SEEA system

The handbook System of Integrated Environmental and Economic Accounting (SEEA, United Nations, 2003), presents approaches for the incorporation of stocks of natural resources in integrated accounts. Table 1 illustrates the types of assets, which can be included in such a SEEA system. Assets are measured in physical terms and – to the extent possible – also valuated in monetary units using different valuation techniques. While physical accounts provide specific information on different types of resource stocks (in different units), monetary valuation allows aggregating different stocks and integration with other economic accounts.

SEEA asset accounts include the three broad categories of "natural resources", "land and surface water" and "ecosystems". Work on resource stocks in the EXIOPOL project will focus on selected items in categories one and two. In particular, EXIOPOL will cover selected mineral and energy resources, which include subsoil deposits of fossil fuels, metallic minerals and non-metallic minerals and certain types of land (e.g. land that could be transformed into agricultural land). See below for more details.

Table 1: SEEA 2003 classification of assets

EA.1 Natural Resources
- EA.11 Mineral and energy resources (cubic metres, tonnes, tonnes of oil equivalents, joules)
- EA.12 Soil resources (cubic metres, tonnes)
- EA.13 Water resources (cubic metres)
- EA.14 Biological resources
  - *EA.141 Timber resources (cubic metres)*
  - *EA.142 Crop and plant resources, other than timber (cubic metres, tonnes, number)*
  - *EA.143 Aquatic resources (tonnes, number)*
  - *EA.144 Animal resources, other than aquatic (number)*

EA.2 Land and surface water (hectares)
- EA.21 Land underlying buildings and structures
- EA.22 Agricultural land and associated surface water
- EA.23 Wooded land and associated surface water
- EA.24 Major water bodies
- EA.25 Other land

EA.3 Ecosystems
- EA.31 Terrestrial ecosystems
- EA.32 Aquatic ecosystems
- EA.33 Atmospheric systems

Memorandum items – Intangible assets related to environmental issues (extended SNA codes)
- AN.1121 Mineral exploration
- AN.2221 Transferable licenses and concessions for the exploitation of natural resources
- AN.2222 Tradable permits allowing the emission of residuals
- AN.2223 Other intangible non-produced environmental assets

According to SEEA, for each category of assets, the stock has to be detected at the beginning and the end of an accounting period, in order to monitor changes in the asset. Changes in the level of stocks during one accounting period are the result of either economic activities or natural processes. These changes can be classified into “changes due to transactions”, “additions to stock levels”, “deductions from stock levels” and “other changes in stock levels”. Table 2 provides an overview of these changes for different types of assets; cells, where entries are in principle possible, are shaded in grey.

Changes due to transactions include gross fixed capital formation, i.e. net changes in produced assets that are continuously used in production processes for more than one year. These changes refer to tangible fixed assets (dairy cattle, fruit trees, etc.), intangible fixed assets (mineral exploration) and additions to the value of non-produced assets (such as land improvements). Furthermore, changes in inventories belong to this category, including stocks of produced goods, which are used only once (e.g. cattle for meat production).

Additions to stock levels are founded in discoveries of new reserves, in reclassifications due to change in quality or function (e.g. transformation of agricultural land into built-up land), and in natural growth of biological assets (such as forests).

Deductions from stock may be caused by the extraction of natural resources (i.e. reductions in the level of exploitable subsoil resources), the environmental degradation of non-produced assets, and – as in the addition case – by reclassifications.

Additionally, other changes in stock levels can occur (e.g. due to catastrophic losses, degradation of produced assets not elsewhere covered, etc.).

The SEEA concept of full asset accounts is comprehensive and well-structured. However, for practical use it is in many cases too detailed, as required data is missing for many countries.

Table 2: Structure of asset accounts in the SEEA framework

	Produced assets	Natural resource stocks				Land
		Mineral and energy	Water	Biological resources		
				produced	non produced	
Opening stocks						
Changes due to transactions						
Gross fixed capital formation						
of which land improvement						
Changes in inventories						
of which work in progress on cultivated assets						
Consumption of fixed capital						
Acquisitions less disposals of non-produced assets						
Additions to stock levels						
Discoveries						
Reclassifications due to quality change						
Reclassifications due to change of functions						
Natural growth						
Deductions from stock levels						
Extraction of natural resources						
Reclassifications due to quality change						
Reclassifications due to change of functions						
Environmental degradation of non-produced assets						
Other changes in stock levels						
Catastrophic losses and uncompensated seizures						
Degradation of produced assets						
Nominal holding gains/losses						
Change in classifications and structure						
Closing stocks						

In order to integrate stock data into the flow accounts, SEEA suggests introducing additional rows and columns to the accounting framework. It is important to note that opening and closing stocks as well as information on changes in stocks (see above) are reported outside the core matrix, as these numbers must not be included in the calculation of total inputs and outputs in the flow framework.

On the one hand, these extensions refer to those parts of the matrix relating to capital, allowing to illustrate the use of produced assets and land by type of asset and by sector in the SNA capital account. It should be noted that land is a non-produced asset, but one which has always been included within the SNA asset boundary. Therefore, enhancements to the value of land brought about by land improvement or just the costs of ownership transfer are included under the category of "capital formation" (SEEA, 2003). It should also be noted that areas of land used for different purposes (agriculture, forestry) is already covered by the land accounts in the environmental extensions of the data base (see separate chapter on land accounts in this report).

More important for EXIOPOL is the inclusion of an additional row and column for asset accounts of natural resources. In these types of stock accounts, 4 entries are required: opening stocks at the beginning of the accounting period (outside flow matrix), natural resource extraction (reported in the flow matrix, but in the stock account with negative value), information on stock changes (e.g. due to new discoveries) and closing stocks at the end of the reporting period (the latter two again outside the flow matrix).

1.4.2 Suggestion for work plan on resource stocks in EXIOPOL

In EXIOPOL, only a limited amount of resources will be available to work on issues related to resource stock accounts. Therefore, several decisions have to be taken, in order to limit the amount of work to a realistic scope, while still providing information, which is of value for the users of the data base, e.g. modelling groups applying integrated economic-environmental modelling. It is therefore suggested to focus on selected natural resources, for which sufficient data are available and integrate them into the EXIOPOL data base as pilot data sets. It has to be decided at a later stage, whether these pilot data is included in the main data base or in a separate module on stock accounts. It is also suggested that in the EXIOPOL database, information on stocks will only be added in physical units (e.g. tons of metal reserves), skipping the part of the economic valuation of the resource stocks.

Natural resources

For natural resource accounts, four entries would be required to establish full accounts for one reporting period (see above). The entry on resource extraction can be directly taken from the module on materials, where all biotic and abiotic raw materials are included. Additional data is required on the opening stocks and other stock changes, from which the closing stocks can be calculated.

With regard to the qualities of reserves, different categories need to be distinguished (see also USGS, 2007):

- proven reserves that can be technically and economically extracted at current conditions,
- proven reserves that can not be exploited due to either technological or economic reasons, and

- geologically probable, possible and speculative reserves, which are still to be detected.

The SEEA system suggests including all three categories in the accounts on subsoil deposits of minerals and fossil fuels. In EXIOPOL it is suggested to focus only on categories 1 and 2.

Yearly data on proven reserves will likely be available for fossil fuels, as data situation is quite satisfying (see below). In this case, full natural resource accounts could be established, with opening stocks, extraction, stock changes due to new discoveries and closing stocks. In other cases, where data availability is lower and only single numbers for currently known reserves can be extracted, without being able to allocate specific discoveries of new reserves to specific years, it is suggested to include this data directly as "closing stock" in the EXIOPOL data base.

A decision must also be taken with regard to the categories of natural resources, for which natural resources stock data shall be collected. Is it suggested to focus work in EXIOPOL on the three quantitatively most important metals (iron, aluminium, copper) and on fossil fuels (coal, oil, gas), with the objective to compile data for as many countries as possible. If it turns out that data on other metals and minerals is easily available, the work programme can be extended.

As mentioned above, estimations on future capacities of the exploration and mining industries will be necessary in addition to data on overall stock sizes. It is intended to use both existing outlooks on future extraction and production levels (which are available in particular for fossil fuels in energy outlooks) as well as consulting publications and studies by mining and engineering institutions.

Possible data sources for natural resource stocks:

With regard to fossil fuels, data coverage is in general better than for minerals. The BP Statistical Review of World Energy, a yearly publication (see BP, 2007 for the most recent edition) provides data of the world energy markets, including, among others, information on oil, gas and coal stocks, disaggregated by countries. The data was used in an extensive report of the German federal agency for earth sciences and resources (BGR, 2006), which gives exact insights in trends in supply and demand of mineral resources. Another yearly publication reporting on reserves of fossil fuels is the International Energy Outlook published by the US Energy Information Administration (see US EIA, 2007 for the latest report). Data is also available from the International Energy Agency in Paris.

With regard to minerals, the US Geological Survey (USGS) is one of the main data providers. USGS publishes "Mineral commodity summaries" (see USGS, 2007) on an annual basis, which report on the reserves in the main supplier countries. These reports also provide a very detailed classification of different forms of reserves. In its mineral yearbooks, additional detailed information on specific metals and minerals is available. Other data sources include other national geological institutes, such as the German Federal Institute for Geosciences and Raw Materials.

Some of the mentioned literature also reports on likely future levels of extraction by country and material. Further information on estimations on future mining capacities will be collected from publications of international mining institutes and organisations, such as the World Mining Congress (www.wmc.org.pl), the World Coal Institute (www.worldcoal.org), the International Iron and Steel Institute (www.worldsteelorg) or International Aluminium Institute (www.world-aluminium.org).

Land

Data on actual land areas used for agricultural and forestry purposes is collected in the sub-module on land in the environmental extensions (see separate chapter below).

In this task dealing with natural resource stocks, focus will be put on possible transformations between different types of land areas. In particular, estimations on the potential availability of new agricultural areas in different countries will be collected, which can then be fed into models as restrictive factors for agricultural production in the future.

Possible data sources for land:

Data from FAOSTAT, which is used for the land accounts in the environmental extensions, can not directly be used for this purpose, as only actual land use is reported. Other data sources are therefore required. One option could be the Global Agro-Ecological Zones (GAEZ) model by IIASA and FAO (2000). This model provides estimations on the land areas with potential for rain-fed or irrigated cultivation for different world regions. The model also illustrates which land transformations would be required (e.g. clearing of forests), in order to expand the production areas. Possibly other sources exist and will be checked at a later stage in the EXIOPOL project.

2 Data sources, transformation-problems and key choices

This chapter is subdivided by environmental extensions (EE):

- natural resource inputs into the economy (2.1 materials, 2.2 land, 2.3 water, 2.4 energy), and
- residuals (2.5 emissions, 2.6 waste).

Section 2.7 reflects on the Ecological Footprint and its relation to the several environmental extensions.

The data issues are jointly presented and discussed for EU and RoW because they are widely overlapping.

Each EE section is further divided into

- General presentation of data availability (overview)
- Pitfalls and problems for use and transformation to EXIOPOL data base
- Key choices and proposals how to overcome problems

2.1 Material inputs

Issues related to natural resource use and resource productivity have experienced a rise on the policy agenda in the past 10 years, in Europe, the OECD and beyond. Material flow accounting and analysis (MFA) developed into a widely applied method for collection and assessment of material flow data and MFA data sets are increasingly available on the national and international level. Since publishing of a handbook on economy-wide material flow accounting by Eurostat (2001), MFAs on the national level have been mostly compiled with this standard reference method (the handbook is currently being updated in collaboration between Eurostat and the OECD).

It is important to note that the conception of the EXIOPOL data base determines that only data on domestic material extraction is considered and no physical import and export data is included. For the calculation of indirect (or embodied) material requirements, input-output analysis on the international level has to be applied, using the economic core of the data base (monetary SUT or IOT plus monetary trade data) and the extensions by material extraction data in physical units (see also Giljum et al, 2007 for a description of multi-regional IO-MFA models). The database created in EXIOPOL can thereby be used to calculate indirect material flows of traded products in terms of so-called "Raw Material Equivalents (RME)". RMEs illustrate, for example, which amounts of raw materials (fossil fuels, primary ores, etc.) were required along the production chain in order to produce an imported car; the weight of the car itself as the final product, however, cannot be calculated with this method (this kind of data can be found in foreign trade statistics).

Compared to the other environmental categories, the extension of the SUT or IOT with data on material extraction seems to be less problematic. On the one hand, European and global data sets are available and can be used in the EXIOPOL project. On the other hand, the link to the SUT or IOT is rather straightforward, as only a few sectors are involved in the extraction of primary materials.

2.1.1 Overview: potential data sources and availability for material inputs

A large number of national MFA studies have been presented for developed countries, (for example, Adriaanse et al., 1997; Matthews et al., 2000; Poldy and Foran, 1999; Statistics Switzerland, 2006) and transition economies (Hammer and Hubacek, 2002; Mündl et al., 1999; Scasny et al., 2003). Concerning countries in the global South, economy-wide MFAs have been compiled for Brazil and Venezuela (Amann et al., 2002), for Chile (Giljum, 2004), for Mexico (Gonzales, 2007), for Ecuador (Vallejo, 2006) and for China (Xu and Zhang, 2007).

2.1.1.1 European MFA data

Eurostat, the European statistical office, has commissioned research institutions (the Wuppertal Institute, the IFF / Institute for Social Ecology) to compile MFA data sets for the EU-15 countries (Eurostat, 2002, 2005). The most recent data set for the EU-15 currently available (Weisz et al., 2006) covers the time series of 1970 to 2001 and is presented in 12 aggregated material categories (see Table 3).

Table 3: Aggregated material categories in EU-15 MFA data set, 1970-2001

Biomass	food
	feed
	animals
	forestry
	non edible biomass
Minerals	construction minerals
	industrial minerals
	ores
Fossil fuels	coal
	crude oil
	natural gas
	other fossils

Source: Weisz et al., 2006

An updated data set for the EU-25 from 1970 to 2005 is expected to be published in summer 2007 and could be used in the EXIOPOL project. The number of disaggregated material categories officially published is expected to be around 15. Whether more disaggregated categories for use in the EXIOPOL project would be available directly from the authors needs to be checked.

In addition, Eurostat has started to send out questionnaires to national statistical offices, in order to survey basic MFA data ("standard tables") compiled from national sources. First submissions of national MFA data sets are expected in autumn 2007 and validated data sets can be expected for early 2008. However, it is difficult to anticipate how much countries will provide MFA data through this Eurostat survey. The Eurostat MFA questionnaire contains a comprehensive 3-digit classification for material inputs – more precisely domestic extraction (used) – distinguishing 59 items (see Annex 1).

2.1.1.2 World-wide MFA data

In addition to the country studies listed above, efforts have been undertaken to compile harmonised material extraction data sets also beyond the OECD countries. A first estimation of the material basis of the global economy was presented by Schandl and Eisenmenger (2006) for the year 1999. The authors disaggregate material extraction by 17 world regions and 4 aggregated material categories (biomass, fossil fuels, ores and industrial minerals, construction minerals).

The first global dataset in a time series of 1980 to 2002 was compiled in the framework of the "MOSUS" (Modelling opportunities and limits for restructuring Europe towards sustainability) project, funded by the European Commission (see Behrens et al., 2007) and is presented by SERI on a separate website (www.materialflows.net). As SERI was the responsible partner for the compilation of this data base, this data set could be used (in improved and updated form, see below) in the EXIOPOL project.

In the MOSUS project, resource extraction data, disaggregated by more than 200 raw material categories, has been compiled for 188 countries in a time series from 1980 to 2002, taking into account changes in frontiers due to splitting up of former USSR, Czechoslovakia, Yugoslavia and PDR of Ethiopia, as well as reunification of Germany in 1990. The method for compiling data also followed the Eurostat (2001) convention.

The MOSUS MFA database was developed mainly from international statistics available from the International Energy Agency (IEA), the US Energy Information Administration (US EIA), the Food and Agricultural Organisation of the United Nations (FAO), the United Nations Industrial Commodity Statistics, United States Geological Survey (USGS), the World Mining Congress, and the German Federal Institute for Geosciences and Natural Resources (BGR) (see Giljum et al., 2004 for details).

It should be noted that coverage of construction minerals in official statistics is still insufficient, particularly in non-OECD countries. An estimation procedure based on GDP/capita levels and trends in population growth was thus applied for all countries in the MOSUS data set, where no data with sufficient quality was available. Based on expert interviews, the numbers for annual per capita extraction of construction minerals were assumed to range from one ton in least developed countries to ten tons in industrialised countries.

In addition to used material extraction, i.e. materials that enter the economic system for further processing, the database also includes estimates on unused extraction, i.e. overburden from mining activities and unused residuals of biomass extraction. Factors to calculate UDE were taken from other MFA studies and reports published by geological institutes.

Data on unused extraction is necessary to calculate some of the material flow-based indicators, such as Total Material Requirement (TMR) and Total Material Consumption (TMC).

It has to be noted that data quality on unused domestic extraction in the MOSUS database is significantly lower compared to used extraction. Country- and material-specific factors were only available for a limited number of countries, while for most countries, in particular outside Europe, average (regional or even global) factors had to be applied.

2.1.2 Transaction issues

The major transaction issue concerns the allocation of material extraction data to products or industries in the SUT or IOT.

In contrast to e.g. emissions of greenhouse gases, which origin practically in all economic sectors, raw materials are only extracted by a very limited number of industries. Therefore, the very detailed material input data sets (e.g. covering more than 200 raw materials in the case of the MOSUS MFA data) should be aggregated, in order to link material extraction data to the products/industries available in the SUT or IOT.

An intuitive solution would be to allocate the extracted raw materials to the corresponding extraction sectors, for example, iron to the iron ore extraction sector, copper to the copper extraction sector, aluminium to the aluminium extraction sector, etc. However, aggregation of the SUT or IOT might preclude this procedure, if e.g. only one sector for mining of metal ores is available. In some IO tables on the national level, there exists even only one sector for all categories of “mining and quarrying”.

Therefore, the level of aggregation of the primary material extraction data and the allocation procedure largely depend on the selection of the number of products/industries disaggregated in the SUT / IOT (either in the original table or additionally split up in the EXIOPOL project as described in the DoW).

Additionally, it is of advantage, if the same levels of aggregation are applied across different environmental categories (for example, number of crops with regard to land, water use and material data).

A sufficient number of disaggregated material categories is required, in order to link material flows to environmental problems caused by certain flows and to investigate the economic driving forces inducing extraction and use of specific materials. If the number of material extraction sectors remains unsatisfying, an approach could be followed, which allocates primary extraction not to the extraction sector itself, but to the sector receiving specific material inputs at the 1st stage of processing (see Schör, 2006).

As Schör (2006) points out, a miss-assignment in the first steps of production will lead to larger errors than a biased allocation at later production stages, as the processing of materials in the first production steps follows rather specific processes with particular input relations. Whereas in later production stages, the original raw materials are mixed into semi-finished and finished products and distributed over a much larger number of sectors. Examples of this type of allocation include allocation of iron ore extraction to the iron and steel sector or the allocation of natural gas extraction to the sector manufacture and distribution of gas.

2.1.3 Key choices with regards to material inputs

2.1.3.1 Selection of data sets

Europe:

For Europe, we suggest to take the upcoming EU-25 data set by IFF/Wuppertal (time series of 1970-2005) as the starting point. If data of sufficient quality is delivered by the national statistical offices as part of the Eurostat process, we might replace data either for selected countries or the whole EU later in the project. Important issues, which still need to be clarified:

- Which level of disaggregation will be publicly available in the EU-25 data set? This issue links to the issue of (dis)aggregation in the next heading.
- What about updates beyond 2005? Will they be covered by data from the national statistical institutes?

RoW:

Ror all other countries/regions outside Europe, we suggest to take the MOSUS MFA data base as the starting point, as data is fully available through SERI.

Several tasks will need to be performed in the EXIOPOL with regard to improvements and updates of the MOSUS MFA data base:

- Harmonize data with / replace data by new official MFA data sets (e.g. OECD and national MFA data sets, if of sufficient quality).
- Harmonize primary data: currently a large number of primary data sources is used and it is the aim to reduce primary data sources to a limited number of best-quality sources. For example, in the field of extraction of fossil energy carriers, where data sources should also be harmonised with environmental extensions in the field of energy (see below in this scoping report).
- Replacing estimated data through national statistics for specific material categories, particular in the area of construction minerals. Possible data sources are USGS; World Mining Congress; UN ICS and others.
- Update of the whole data base (up to 2005 in the first step, 06/07 later in the project)

2.1.3.2 Level of (dis)aggregation

Another key choice refers to the level of (dis)aggregation of specific materials / material groups which is associated with the level of (dis)aggregation of products/industries in the monetary SUT or SIOT accounts.

To our opinion, a detailed level of disaggregation should be achieved, in order to allow accounting and modelling of a larger number of material categories and to link specific material flows to specific environmental impacts. This, however, makes only sense and is feasible if also the corresponding products/industries are disaggregated.

The DoW states that around 10 additional sectors should be split up in the agricultural sectors, around 10 in the mining sectors and around 10 in the area of housing and energy using equipment. If this level of detail can be achieved, this would solve many of the allocation problems discussed above, as materials could be allocated to the largest extent directly at the point of extraction. The issue of the number of industries/products covered by SUT or IOT in Europe and Rest of the World is subject to the scoping paper related to work packages III.2.a and III.3.a.

Key issues with regard to the issue of (dis)aggregation: The materials or groups of materials disaggregated in this part of the environmental extensions should be harmonised with other environmental categories, in particular with regard to biomass. Several close links can be identified, e.g. with regard to land use (issue of grazing/pasture), water use, etc. In addition, the main data source (FAOSTAT) will be common for the environmental extensions material, land and water.

- If the SUT / IOT will not disaggregate to a sufficient number of products/industries, the approach as described by Schör (i.e. linking material extraction to the receiving sector at the 1st stage of processing, see above) will be tested and applied where appropriate.

2.1.3.3 Used/unused extraction

Another key decision to be taken refers to the issue of considering unused domestic extraction (UDE) linked to the extraction of economically used materials. As described above, UDE data is required to calculate comprehensive MFA indicators such as TMR and TMC. However, but data availability and quality is still unsatisfying for many countries (in particular, non-OECD countries) and improvement of UDE estimates would require significant resources; i.e. primary data would need to be collected in a bottom-up approach (e.g. through interviews with experts or through collection of data on the level of single enterprises in the mining sector).

Our suggestion therefore is to focus the work in EXIOPOL on the improvement and update of data on used extraction. However, data on UDE shall also be included in the EXIOPOL data base taking the most recent and publicly available data from the literature. A limited amount of time will also be reserved to provide a quick check of important new publications in the past few years in this field, in particular from national geological institutes.

2.2 Land

Land is a natural resource different from materials. Whereas the latter constitute flows of natural materials that are physically processed into goods, land constitutes a natural asset that is utilised but not as such physically incorporated into products. Land area can be regarded as a natural stock providing various services to human activities.

Yet, land area is an important production factor although it is more or less fixed and not increasable. Agriculture and forestry are the most important economic activities using one particular service function of land. Those economic activities utilise land area to grow biomass; a renewable material resource which is further economically used for processing of goods. The global land area available for growing biomass is limited. This implies that the total amount of biomass material that can be grown for use in economic processing is also limited. Basically, there are two means to increase the amount of biomass materials:

(1) Increasing the land area utilised to grow biomass through land use changes from e.g. natural forest area (e.g. rainforests) into arable land.

(2) Increasing the hectare productivity or yields through e.g. technological progress; i.e. increasing the amount of biomass material harvested per hectare (expressed in tonnes per hectare).

There are indications that the EU economy is already using more biomass material as they grow on their own land area. Through net-imports of biomass-based products, the EU is indirectly utilising land area in other world regions to meet its consumption needs. The global land use of the EU15 exceeds the domestic agricultural area by about one fifth (Steger 2005; Bringezu et al. 2007).

Recording land area which is used to generate biomass material for economic processing in the EXIOPOL database seems of high policy relevance. Recent EU policy efforts, such as e.g. the increased use of bio fuel, will have implications on land use in Europe and beyond.

Built-up area denotes land use for settlements and infrastructures. Unlike land use for biomass growing, built-up area serves no direct physical inputs to the economy. It provides rather a service of “hosting capital goods” and it is hence not directly linked to flows of materials into the economy. International data on build-up area are not available.

The Ecological Footprint (EF) is a composite indicator expressed in artificial land-use units. Its accounting procedure is not based on actual land uses but on material flows (namely, biomass material resources and CO2). The incorporation of EF into the EXIOPOL IO framework is discussed separately (see excurse in section2.7).

2.2.1 Overview: potential data sources and availability for land use

FAOSTAT (http://faostat.fao.org/site/291/default.aspx), the statistical system of the Food and Agriculture Organisation of the United Nations (FAO) is clearly the main intentional data source for agricultural and forestry land use for about 200 countries. Currently, FAOSTAT is being restructured.

Land use data can be found in the ResourceSTAT module. The classification is presented in Table 4. The land use categories 'agricultural area' (incl. its sub-items) and 'forest area' are evidently to assign to the two NACE divisions 01 and 02.

Table 4: Classification of land use in FAOSTAT's ResourceSTAT-Land database, example data for Germany 2005 (1000 ha)

<table>
<tr><td colspan="6">Country Area
35,703.00</td></tr>
<tr><td colspan="5">Land Area
34,877.00</td><td rowspan="4">Inland Water

828.00</td></tr>
<tr><td colspan="3">Agricultural Area
17,030.00</td><td rowspan="3">Forest Area

10,649.00</td><td rowspan="3">Other Land

7,198.00</td></tr>
<tr><td colspan="2">Arable Land and Permanent Crops
12,101.00</td><td rowspan="2">Permanent Meadows and Pastures
4,929.00</td></tr>
<tr><td>Arable Land
11,903.00</td><td>Permanent Crops
198.00</td></tr>
</table>

In addition, agricultural land use data can also be found in more detail. The FAOSTAT ProdSTAT module (and also the FAOSTAT core production data) contains detailed agricultural production data, area/stock and yield data for crops, live animals and livestock primary and processed (the latter is also termed livestock products). This enables to record at least arable land and permanent crops land on the detailed level of some 200 crops. However, it is not clear whether the sum of those detailed area data equal to the total 'arable land and permanent crops' as reported under the ResourceSTAT module.

2.2.2 Transaction issues: Allocation of land use to industries/products

A crude allocation of land-use to NACE 01 "agriculture" and NACE 02 "forestry" is straightforward.

In addition, the FAOSTAT data allow a more detailed allocation to groups of agricultural primary commodities (http://faostat.fao.org/site/384/default.aspx), if the SUT or symmetric IO tables compiled in the EXIOPOL project are also further disaggregated with regard to agricultural (sub)sectors. At least arable land use and permanent crops land use can be allocated to the crops and fruits among the ca. 200 primary commodities. The result, however, needs to be crosschecked with the total land-use of the categories ‘arable land’ and ‘permanent crops’ (from ResourceSTAT).

Note, that these primary crops also comprise fodder crops. This brings us to the allocation of ‘permanent meadows and pastures’ to products. An allocation of this land use category to certain livestock and/or dairy products seems not possible. Biomass from grazing (an item as used in economy-wide Material Flow Accounts, see section 2.1) seems to constitute the appropriate product which can be attributed to this land use category.

Attribution of ‘forest area’ to the NACE sector 02 seems easy on the first spot. However, a differentiation by wooden primary products is more complicated because no yield-factors (e.g. m^3/ha or t/ha) are provided by the ForesSTAT data module. The latter would need to be derived from other sources. Whether or not further disaggregation is required with regards to forestry also depends on the level of disaggregation of the IO tables.

2.2.3 Key choices with regards to land use data

Level of (dis)aggregation of the SUT/SIOT determines the land-use data sources and categories:

In the case of 60 by 60 industries the broad categories of FAOSTAT-Land can be used. The allocation of agricultural land to NACE 01 and forest area to NACE 02 is straightforward. If a more detailed resolution is applied for NACE 01 and 02, other FAOSTAT archives are to be used. Arable land and permanent crop land can be easily related to so-called primary crops. In the case of permanent pasture, methodological-statistical problems arise to find the corresponding product (most likely the material item ‘grazing’). The same applies for forest area which can only be related to the total biomass from forestry, but not product-specific (e.g. sawnwood, pulp and paper etc.).

Built-up area: insufficient data and difficulties to allocate to economic activities

There is no data for built-up area; only estimates exist. In addition, no auxiliary information is consistently available to develop a robust estimation method for allocating built-up area to economic activities. It is recommended to skip built-up area from the EXIOPOL data base.

2.3 Water

Although not promised in the DoW, the following section explores the possibility of including water use (irrigation, process, cooling). Linking fresh water input to the multi-regional IO framework would enable to calculate "virtual water" flows associated with imports to Europe.

2.3.1 Overview: potential data sources and availability for water use

Two main data sources have been identified for water use:

- FAOSTAT – AQUASTAT: online database (note that current re-structuring of FAOSTAT may change the domain names)
- Study "Water Footprints of Nations" by UNESCO-IHE Institute for Water Education

…whereby the latter is widely based on former.

The FAOSTAT – AQUASTAT data on water use are distinguished in three categories:

- Agriculture water use (add definition)
- Industry water use (add definition)
- Domestic water use (add definition)

Time-wise, the water use data are given for 5-year periods (e.g. 1999-2003).

Country coverage is fairly complete, although some single countries might be missing or contain extrapolated data from previous years.

The UNESCO-IHE publication contains the following relevant data sets (Volume 2) which are also downloadable from the internet:

- Annex V: total water withdrawal, and breakdown into agricultural, industry, and domestic [m3/yr]
- Annex VII: average crop yield by country and by primary crops [ton/ha]
- Annex VIII: average crop production by country and by primary crops [ton/yr]
- Annex XIII: virtual water content of primary crops by country [m3/ton]
- Annex XIV: virtual water volume of primary crops by country [m3/yr]

Note: no data is available for cooling water (which could be attributed to electricity generation).

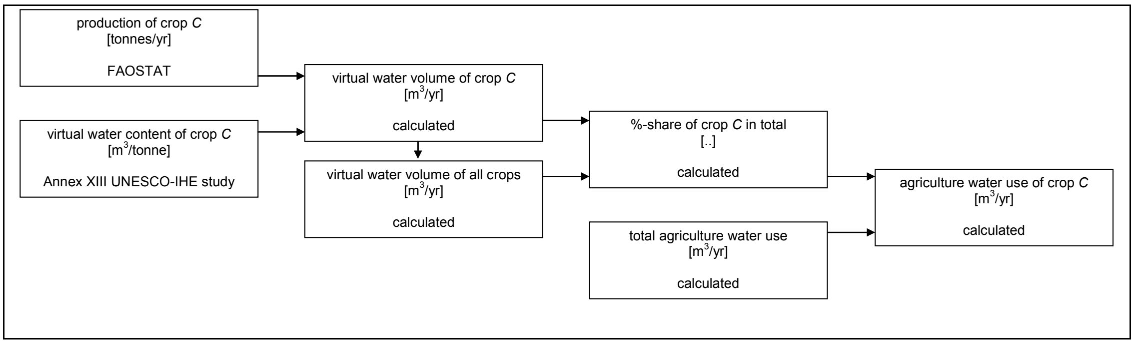
2.3.2 Transaction issues: Allocation of water use to industries/products

For the EXIOPOL database, the three categories of water use need to be allocated to economic entities of direct use (industries/products; households). For the agriculture water use this allocation is straightforward whereas the allocation of domestic water and industrial water is less straightforward.

2.3.2.1 Allocation of agriculture water use to the agriculture sector (NACE 01) and breakdown by ca. 200 primary crops

Obviously, agriculture water use can be allocated to industry NACE 01.

In addition, above data sources allow a detailed breakdown of the total agriculture water use to ca. 200 primary crops. The allocation procedure is illustrated in the following flow-chart:



Note that the differentiated agricultural water use by primary crops would be placed as "water use by products" in a SUT scheme, whereas the total agriculture water use would be placed under "water use by industry" in a SUT scheme

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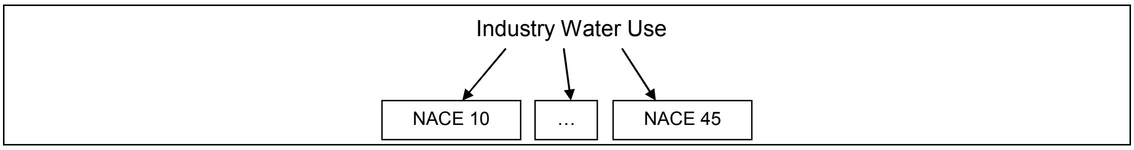
2.3.2.2 Allocation of industry water use to the manufacturing sectors (NACE 10 to 45)

Industry water use needs to be allocated to manufacturing industries (NACE 10 to 45):



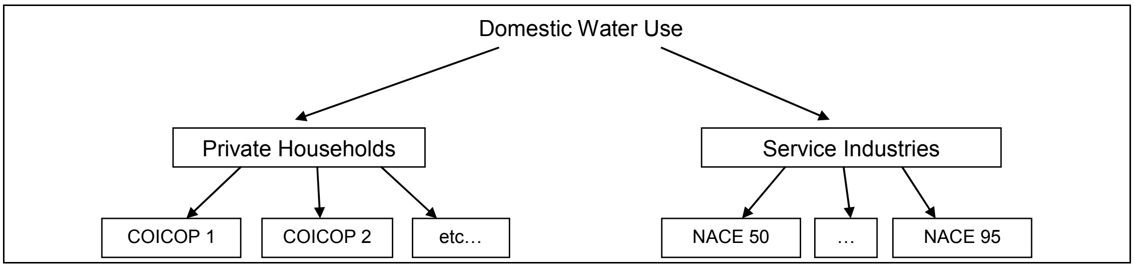
Additional information is required in form of auxiliary variables. These may include:

- Gross value added or output by industry [$]
- Output by products [tonnes] : could be derived from
  specific export by products [tonnes/$] * output by products [$]
- Employed persons by industry [persons]

- LCI coefficients [m³/tonnes] * Output by products [tonnes]

2.3.2.3 Allocation of domestic water use to the private households and service sectors (NACE 50 to 95)

Domestic water use needs to be allocated to private households and service industries (NACE 50 to 95):



Additional information is needed for this split.

In a first step the distinction has to be made between private households and service industries. In a second step, the part allocated to service industries needs to be broken down into the NACE-2-digit classes 50 to 95. For this, a number of auxiliary variables could be used:

- Gross value added or output by industry [□]
- Employed persons by industry [persons]

2.3.3 Key choices

- Excluding cooling water? –> yes
- Shall we distinguish ca. 200 primary crops?
  –> Yes, but grouped to some 20-40 as proposed by the IPTS agri-unit
- Which auxiliary variable shall be used for splitting industry water use?
- Which additional information can be used to split domestic water use into households and service industries?
- Which auxiliary variable shall be used for splitting service industries' water use?
  –> employed persons if available!

2.4 Energy

The use of energy is one of the most important resource input to nowadays economies.

2.4.1 Overview: potential data sources

There are two main potential data sources:

- NAMEA-type tables for energy use (or, alternatively energy accounts) record energy data according to the rules of National Accounts, i.e. fully compatible to IO tables. Usually, the use of several energy products is shown by about 60 NACE industries is given. A distinction is made between primary energy products (such as coal, crude oil, natural gas) and secondary products (such as coke, petroleum products). The energy NAMEA standard table as developed by Eurostat gives methodological guidance.
- Energy balances and/or statistics report energy data not in line with National Accounts principles and are hence not directly linkable to IO tables. The IEA energy balances (which are widely compatible with Eurostat's energy balances) employ technology- and/or process-based classifications which are difficult to link to economic activities as used in National Accounts (e.g. NACE or CPA divisions) in certain cases (particularly transport). The "Energy Statistics Manual" jointly published by OECD, IEA, and Eurostat (2004) gives a good overview on the systematics and classifications of energy balances and statistics (http://www.iea.org/textbase/nppdf/free/2004/statistics_manual.pdf).

The following sections provide an overview on data availability for the several sources.

2.4.1.1 NAMEA-type tables for energy use (or, alternatively energy accounts)

NAMEA-type tables for energy use are available in a number of European countries. Eurostat has collected NAMEA-energy tables comprehensively for the first time in a 2006-NAMEA-survey. The data availability and quality is moderate. In particular, the breakdown by industries is seldom on the A60-level. The Eurostat 2006-NAMEA-questionnaire asked for two energy use variables; namely total energy use and emission-relevant energy use.

Very detailed NAMEA-type tables for energy (or energy accounts) with breakdowns by several primary and secondary energy products are available from a few European countries; e.g. Belgium, Denmark, Germany, UK – but only directly available from statistical offices.

The data availability for the RoW is scattered and can be assessed as poor. Some selective results from internet search:

China: The Statistical Yearbook contains quite detailed data on energy consumption by energy carriers and by industries (classified quite close to NACE 2-digit). http://www.stats.gov.cn/english/statisticaldata/yearlydata/

India: Consumption of several energy carriers by very crude groups of industries. http://www.mospi.gov.in/mospi_energy_stat.htm

Australia: A 2001 publication of energy and emission accounts (data for the 1990ies)

2.4.1.2 Energy balances and/or statistics

Energy statistics are provided by Eurostat (for EU countries) and by IEA/OECD for almost all countries in the world. Eurostat, IEA and the United Nations Economic Commission for Europe (UNECE) collect annually energy statistics via a joint questionnaire. Hence, energy statistics are internationally harmonised. Availability (i.e. country, time coverage) and quality can be assessed as good. The most common representations of energy statistics are commodity balances (in varying commodity specific natural units) and energy balances which are derived from the commodity balances. In the latter, the natural units of the commodity balance are transformed into energy units by multiplying by appropriate conversion equivalent for each of the natural units. The IEA and Eurostat use energy units of tonnes of oil equivalents (toe) defined to be 41.868 Gigajoules. Many countries use the Terajoule as the unit of their national energy balance (see OECD/IEA 2004).

The commodity balances and energy balances show the supply and the use of energy commodities. The most important supply-items comprise production, import and exports. The use-items comprise two main blocks – transformation and final use, each broken down by further items. The Eurostat energy balances have slightly different format than the IEA energy balances (see Annex 2).

2.4.2 Transaction issues: Allocating energy use to industries/products

A number of European countries are providing quite good NAMEA-type tables for energy use (Denmark, Italy, UK, Germany, Netherlands, Norway etc.). These data are collected and provided by Eurostat. Here, the allocation to NACE items (e.g. A60-level) is already given.

However, for the remaining European countries and particularly for the RoW-regions we have to derive NAMEA-type energy data from international energy balances as provided by Eurostat and IEA.

The very first step is to establish a correspondence-key linking from energy balance items to CPA-2-digits plus households. Since we are interested in the energy use, we will have to consider only the use-side of the energy balance, i.e. transformation and final use of energy. Many of the energy balance items can directly linked to the production of certain CPA-2-digit-level product groups.

Note, that the energy balance items are closer related to products than to industry branches. Hence, we have to link first to products (which is feasible in the EE-SUT framework).

However, in some cases the energy balance item is related to more than one 2-digit product. For instance, the energy balance item “”road transport” needs to be distributed over a number of 2-digit product groups and households. Or, the energy balance item “commerce and public services” needs to be distributed over a number of 2-digit services. For this distribution we have to make use of auxiliary variables such as e.g. employment, production output etc.

If we apply the above correspondence key for the total of all energy commodities (expressed in toe) we obtain already a NAMEA-type vector of energy use by 60 CPA-2-digit product groups.

If we are interested in energy use differentiated by energy commodities (e.g. distinguishing solids, liquids, gaseous, others) we may need additional data manipulation and transformation steps.

One particular data problem is related to conceptual differences between energy statistics and the System of National Accounts (SNA). Energy statistics are following widely the territory principle, i.e. energy supply and use is recorded which take place on the national territory, i.e. from domestic residents and from foreign entities. The SNA is following the resident principle as should do the environmental extentions. Hence, one needs to add activities of residents operating abroad (e.g. international transport services provided by domestic residents) and deduct activities of foreign entities operating inland (e.g. tourists driving a car in the respective country). The difference between both concepts can be significant (e.g. for Denmark and Luxembourg).

2.4.3 Key choices with regards to Energy

NAMEA-type data are only readily available from a limited number of European countries. Hence, we have to generate our own energy use vectors using IEA and/or Eurostat energy balances. Towards this end, additional auxiliary variables are needed and we have to decide which ones are the most feasible ones. Further, a decision is needed on the detail of CPA product groups and detail of energy commodities.

2.5 Emissions

Emissions are residual material flows resulting from human activities. They are released from the economic sphere into the environment. According to the different compartments of the environment, we can distinguish emissions to air, water and soil.

The DoW lists a number of substances (emissions to air, water and soil) which should be considered – if feasible – in the EE-IO framework. The corresponding table from the DoW is given in Table 5. The objective is to achieve a good coverage of emission-related environmental themes. There are four environmental themes where operational characterisation methods are well accepted, namely global warming, stratospheric ozone depletion, acidification, and tropospheric ozone formation potential. Also eutrophication is a common environmental theme related to emissions of nutrients to soil and water. Characterisation models are available but not as established and accepted as for the former themes. Toxicity is an environmental theme which is not fully considered in the following due to its huge data requirements. Its integration into the EE-IO framework would require long lists with hundreds of substances which seems not feasible. Instead, a selection of most important substances (e.g. organic pollutants, particulate matter) is envisaged which are commonly subject to externality research. These will be selected in close consultation with Cluster II of the EXIOPOL project, and Table 5 below gives the list resulting from the consultation in the phase that the DoW was produced..

Table 5: List of emissions mentioned in the EXIOPOL DoW and potential data sources

<table>
<tr><th colspan="2">Pressures (‘inventory of interventions’ or ‘environmental extensions’)</th><th>Impacts / Impact indicators</th></tr>
<tr><td>Emissions (air, water, soil)</td><td>Key Data sources</td><td></td></tr>
<tr><td>• GWP substances (CO_2, CH_4, etc.)
• Ozone depleting substances (HCFCs, etc.)</td><td>EU25: Eurostat NAMEA-air project
RoW: UNFCCC Annex 1`parties ; EDGAR/TEAM other countries</td><td rowspan="6"><u>LCA impact categories</u>
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

<u>Ecological footprint (EF)</u>
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.

<u>Total material consumption (TMC/MFA)</u>
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

<u>External costs</u>
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.</td></tr>
<tr><td>• Acidifying substances (SO_2, NO_x, NH_3)
• POCP forming substances (NMVOC)</td><td>EU25: Eurostat NAMEA-air project
RoW: LRTAP convention for UN-ECE members ; TEAM/ EDGAR for other countries</td></tr>
<tr><td>• Eutrophying emissions (NH_3, PO_4, 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</td><td>EU25: LRTAP convention, where incomplete from TEAM
RoW: LRTAP convention for UN-ECE members ; TEAM/EDGAR for other countries</td></tr>
<tr><td>Input of primary resources</td><td></td></tr>
<tr><td>• Primary energy carriers
• Other abiotic resources
• Biotic resources</td><td>EU25: Ongoing Eurostat project and Wuppertal Institute and SERI/MOSUS database
RoW: SERI/MOSUS database, IEA, UNSD, FAO, WMC, etc.</td></tr>
<tr><td>• Land use</td><td>EU25: FAOSTAT, CORINE landcover, others
RoW: FAOSTAT, CORINE landcover, LUCC, NASA</td></tr>
</table>

2.5.1 Overview: potential data sources

In general the availability of internationally harmonised emission data which could be assigned to the EE-IO data framework – i.e. broken down by economic entities (e.g. NACE and/or CPA) – is rather poor. There are some international sources for air emission data which require some manipulations in order to make them compatible to the IO framework. Almost no data is available for emission to water and soil, at least in a form close to the IO framework. In the following, a brief overview is presented.

- Air emissions
  - NAMEA-type tables for air emissions record air emissions fully compatible to the National Accounts principles and are linkable to IO tables. The different air emissions (greenhouse gases, acidifying gases etc.) are shown by the emitting economic activities (NACE divisions). There are two main methodological approaches to generate NAMEA-type tables for air emissions (see draft Eurostat Compilation Guide for NAMEA-air):
    - The "NACE-first-approach" starts with detailed energy accounts. I.e. in a first step NAMEA-type tables are generated for energy use broken down by detailed energy products and NACE divisions. In a second step air emissions are calculated applying e.g. UNFCCC standard emission factors; i.e. the energy use is transferred into emissions.
    - The "inventory-first-approach" starts from the air emission inventories (see next bullet). Here, the technical CRF-classes are cross-tabled with the NACE divisions whereby certain auxiliary variables are used to distribute/attribute certain CRF-classes to NACE divisions. The data quality of NAMEA-air tables based on this "inventory-first-approach" depends very much on the efforts employed by the respective statistical office. Some countries do it very carefully with huge amounts of auxiliary statistical information. Other countries simply use extremely crude keys to link from CRF to NACE (basically according to the CRF labels). Consequently, the quality of European NAMEA-air data based on this approach vary considerably across countries.
  - Air emission inventories are air emission compilations following certain guidelines as agreed under international conventions. There are two international convention based air emissions inventories which are relevant:
    - UNFCCC: United Nations Framework Convention on Climate Change http://unfccc.int/2860.php
    - CLRTAP: Convention on Long-Range Transboundary Air Pollution (with reporting to UNECE/EMEP) http://www.unece.org/env/tfeip/welcome.htm

The substances collected under the two conventions are the following:

Convention on Long-Range Transboundary Air Pollution (with reporting to UNECE/EMEP)	United Nations Framework Convention on Climate Change
CLRTAP	UNFCCCC
	CO_2
	N_2O
	CH_4
	HFCs
	PFCs
	SF_6
NOx	NOx
SO_2	SO_2
NH_3	
CO	CO
NMVOC	NMVOC
PM10	
9 heavy metals	
17 POPs	

Recent efforts resulted in a Common Reporting Format (CRF) for the two inventories. The CRF is a technology- and/or process-based classification widely compatible with the classification used in energy balances and statistics (look at section 8.5 in the document at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_8_Ch8_Reporting_Guidance.pdf). In addition to this, for all fuel combustion related source categories, a further split in fuels is made (see table 1.1 in http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf).
However, the CRF is not compatible with the National Accounts principles and it is difficult to link CRF to NACE divisions in certain cases (e.g. transport).

- Pollution/Emissions Registers are inventories of site or plant specific emissions. They record selected emissions by selected facilities (i.e. they are not complete and hence not representative for the national economy level). They are intended to enable citizens to get information on the factories/plants in their neighbourhood. Usually, the emission data are reported by the respective enterprise on a voluntary basis. The European Pollutant Emission Register (EPER) contains emissions data for some 13000 individual facilities (locations/plants), including about 60 pollutants to air and water: http://www.eper.ec.europa.eu/.

- Emissions to soil
  - Pollution/Emissions Registers may provide some information on emissions to soil in certain, rather seldom, cases.
  - Otherwise, there is no direct data source for emissions to soils, i.e. they need to be estimated on the basis of certain activity data (such as fertilizer and manure use) and corresponding emission factors (see below).
- Emissions to water

- Pollution/Emissions Registers may provide some information on emissions to water in certain, rather seldom, cases.
- Otherwise, there is no direct data source for emissions to water, i.e. they need to be estimated on the basis of certain activity data (such as e.g. population) and corresponding emission factors (see below).

The following sections provide an overview on data availability for the several sources.

2.5.1.1 NAMEA-type tables for air emissions

NAMEA-air are available for a number of European countries. Eurostat has been collecting NAMEA-air from countries for several years. The most recent survey took place in 2006, the next will follow in 2008. The EU27+2 data availability and quality is moderate. Coverage of air pollutants is varying across countries. In most cases: CO2, N2O, CH4, SOx, NOx, NH3, NMVOC, CO; sometimes PM (heavy metals very seldom). Also the level of industry-breakdown is varying; A60-level is rather seldom. All in all, NAMEA-air of good quality are available for some 10 EU countries.

For the RoW the data situation is also rather bad. As mentioned, official air emission accounts are available from the Australian Statistical Bureau (but only 1990ies). For Japan, good data should be available from NIES (National Institute for Environmental Science) or Department of National Accounts, Economic and Social Research Institute (ESRI), Cabinet Office of Japan (http://www.esri.go.jp/index-e.html).

2.5.1.2 Air emission inventories

Harmonised data sets regularly reported by countries to two important international conventions:

- UNFCCC – United Nations Framework Convention on Climate Change

  Data are only available for so called Annex-1-countries, implying that most important countries are missing such as e.g. US, China. Data availability by countries can be viewed at: http://unfccc.int/ghg_emissions_data/information_on_data_sources/items/3816.php

  Substances coverage: CO2, N2O, CH4, HFCs, PFCs, SF6, NOx, SO2, CO, NMVOC

- CLRTAP – Convention on Long Range Transboundary Air Pollution

  Not available for all countries. Country coverage can be viewed under: http://webdab.emep.int/ .

  Substances coverage: NOx, SO2, NH3, CO, NMVOC, PM10, 9 heavy metals, 17 POPs

Methodologies for estimating those air emission data are internationally harmonised. However, air emission inventories are not compatible to SNA. The classification (called Common Reporting Format, CRF) is technology/process-based and cannot be linked easily to NACE A60-level, particularly in the transport area.

2.5.2 Transaction issues: Allocating emissions to industries/products

As already mentioned in the introduction and derivable from the data overview, only a few emission data are available which can be directly assigned to the EE-IO framework. This might be valid for a number of European countries where quite good NAMEA-type tables for air emissions and energy use are provided (Denmark, Italy, UK, Germany, Netherlands, Norway etc.). These data are collected and provided by Eurostat. Here, the allocation to e.g. NACE A60-level is already given.

However, for the bulk of countries and the majority of emissions we will have to make our own estimations.

2.5.2.1 The general approach to estimate emissions

The following general equation is used to estimate emissions:

$$E = AR \times EF \qquad (1)$$

Emission (*E*) is obtained by multiplying a certain triggering activity (*AR*: activity rate) by a certain emission factor (*EF*). Equation (1) assumes a linear relationship between the rate of a certain activity (*AR*) and the actual emissions (*E*) resulting. The emission factor (*EF*) expresses this linear relationship. Technical guidance documents provide such emission factors. They are supposed to facilitate the compilation of national emission inventories under international conventions (e.g. IPCC and EMEP/CLRTAP). Using this classical approach requires – in a first step – collection of activity data and assigning specific emission factors in a second step.

The emissions of a certain pollutant – let's say CO_2 – may be the aggregate sum of a number of activities with related emission coefficients:

$$E_{Pollutant} = \sum_{Activities} AR_{Activity} \times EF_{Activity,Pollutant} \qquad (2)$$

For instance, the emissions of CO_2 result from several activities:

a) combustion of coal
b) combustion of oil
c) combustion of gas
d) pig iron production
e) ...

The associated emission factors vary from activity to activity.

In the EXIOPOL context, we are particularly interested in emissions broken down by economic entities, i.e. products or industry-branches. Hence, the emission term on the left hand receives an additional sub-index representing e.g. 60 product groups (CPA-2-digit), i.e. it becomes a column vector:

$$\begin{matrix} E_{Pollutant,Product1} \\ E_{Pollutant,Product2} \\ E_{Pollutant,Product3} \\ E_{Pollutant,Product4} \end{matrix} = \begin{matrix} \sum_{Product1.Activities} AR_{Product1.Activity} \times EF_{Activity,Pollutant} \\ \sum_{Product2.Activities} AR_{Product2.Activity} \times EF_{Activity,Pollutant} \\ \sum_{Product3.Activities} AR_{Product3.Activity} \times EF_{Activity,Pollutant} \\ \sum_{Product4.Activities} AR_{Product4.Activity} \times EF_{Activity,Pollutant} \end{matrix} \quad (3)$$

Thereby, the very same activity might occur in more than one product group. For instance, activity 1 (let's say the combustion of coal) might occur in the electricity production (product 1) as well as in the metal production (product 2). In this example, we would have the following denotations:

$AR_{Product1,\ Activity1}$: the amount of coal used in the electricity production

$AR_{Product2,\ Activity1}$: the amount of coal used in metal production

The respective associated emission coefficient could be the same, i.e. $EF_{Activity1,Pollutant}$.

2.5.2.2 Activity variables needed

In order to estimate emissions a number of activity variables are required. For most air emissions it is the energy use which can be used as the activity rate (see equation (1)). The energy use (broken down by a number of different energy carriers) is available from IEA international energy statistics covering most countries of the world.

But also further activity data need to be collected. The following Table 6 gives an example. It provides an overview on activity variables needed to estimate UNFCCC greenhouse gas inventories.

2.5.3 Key choices with regards to Emissions

1) Selection of substances

As mentioned in the introduction to this section, there are a number of emissions where it is quite clear that they will be considered. These comprise the air emissions related to prominent environmental themes, namely:

- greenhouse gas emissions to air (CO2, N2O, CH4, HFCs, PFCs, SF6): these are needed to derive Global Warming Potentials
- emissions of CFCs and HCFCs to air: needed to derive Ozone Depletion Potential
- emissions of acidifying substances to air (NOx, SOx, NH3)

Table 6: Activity variables and potential data sources needed for estimating UNFCCC emissions

Substance	Type of emission	Activity variable needed	Potential data source
CO2, N2O, CH4, NOx, CO, NMVOC, SO2	from fuel combustion (CRF 1.A)	fuel use quantity (Joules)	IEA statistics
CO2, CH4, CO, NMVOC, SO2	fugitive emissions (CRF 1.B)	mining quantities (tonnes or Joules)	IEA statistics; USGS
CO2, NOx, CO, NMVOC, SO2	from industrial processes – mineral products (CRF 2.A)	production/consumption quantities of mineral products (tonnes); e.g. cement, lime, soda ash, glass etc	USGS
CO2, N2O, CH4, NOx, CO, NMVOC, SO2	from industrial processes – chemical industry (CRF 2.B)	production/consumption quantities of chemical products (tonnes); e.g. ammonia, ethylene, dichloroetylene, methanol etc.	?
CO2, CH4, PFCs, SF6, NOx, CO, NMVOC, SO2	from industrial processes – metal production (CRF 2.C)	production/consumption quantities (tonnes); e.g. steel, pig iron, sinter etc.	USGS
CO2, NOx, CO, NMVOC, SO2	from industrial processes – other (CRF 2.D)	production/consumption quantities (tonnes); e.g. pulp, paper	FAO
HFCs, PFCs, SF6	from industrial processes – production of Halocarbons and SF6 (CRF 2.E)	quantities (tonnes)	?
HFCs, PFCs, SF6	from industrial processes – consumption of Halocarbons and SF6 (CRF 2.F)	quantities (tonnes)	?
CO2, N2O, NMVOC	Solvent and other product use (CRF 3)	quantities (tonnes)	?
CH4	Agriculture – enteric fermentation (CRF 4.A)	animal population (1000s)	FAO
CH4, N2O, NMVOC	Agriculture – manure management (CRF 4.B)	animal population (1000s)	FAO
CH4, NMVOC	Agriculture – rice cultivation (CRF 4.C)	harvested area (hectares)	FAO
CH4, N2O, NMVOC	Agriculture – agricultural soils (CRF 4.D)	quantities of nitrogen inputs (kg N)	FAO and others
CO2, N2O, CH4, NOx, CO, NMVOC, SO2	Waste and waste water management (CRF 6)	quantities (tonnes)	Eurostat, DG ENV

- emissions of ground level ozone precursor substances to air (NMVOC, CO, NOx, CH4)
- in addition, we will also consider emissions of particulate mater to air

Further, it is envisaged to estimate the N and P (eventually BOD) emissions to water and soil in order to represent the theme of eutrophication. We further have to consider a number of prominent toxic emissions (e.g. formaldehyde, BaP, 1,3 butadiene) and for a selection of POP emissions to air soil, a.o. via pesticide use. This selection of substances is necessary to be able to calculate external costs as an indicator. All in all, we envisage a list comprising 30+ substances.

A practical problem though, is that emission data availability will vary highly in quality. Our list may see some adaptation on the basis of practical data availability. However, the aim is to come up with a considerably more complete picture than the many other efforts in the field of EE I-O that have confined them to mainly energy related emissions.

2) A decision is needed on the detail of CPA product groups (relates to the detailing of IO tables).

3) Estimating/compiling own NAMEA-type tables

It is already quite clear that we will have to set up our own NAMEA-type tables of emissions to air, water and soil. Ready-for-use NAMEA-type tables for emissions of sufficient quality are rather limited and only available for some 10-15 European and RoW countries; and this only for the most common about 8 air emissions. As a consequence, we will have to develop reasonable estimation methods to create our own IO-compatible emission data based on other sources and information. At this stage, we foresee to approach this job as follows:

- energy related emissions can be estimated probably with a quite good reliability by using basic data of IEA on energy use, combined with process- and country specific emission factors. Such emission factors have already been estimated in a variety of contexts, and project partner TNO has used this approach already successfully in former projects. The advantage of this approach over using emission inventory data (that do not cover all countries needed) is that we end up with a consistent data set.
- Other activity related emissions can be estimated in a similar way based on other activity variables, such as material throughput, animal stock, fertiliser use, and the like (see Table 5).
- For sectors or emission types (e.g. to water) where the approaches above do not give a sound estimate, more crude approaches probably have to be used. For several countries (most notably the US and several EU countries) total emissions per sector have been inventoried via various pollution / emissions registers. Nijdam and Wilting (2005) estimated emissions in countries that do not have own emission registries by extrapolation (i.e. using the same emission factor per Euro or $ turnover); this approach can be sophisticated by scaling up or down emissions on the basis of insight in any likely differences in (end of pipe) technology.

It is not very well possible at this stage to indicate in detail which approach in which case will be chosen. While doing the job it will become clear what the possibilities of each approach are. In the coming pilot phase (until month 12) these estimation methods will be tested for 2-4 countries.

2.6 Waste

The definition and treatment of waste in an extended SUT and/or SIOT framework is not evident – waste might be perceived as a product (i.e. with monetary value) or as a residual flow. A material which is disposed of as 'waste' by a certain activity may become a product because another economic agent can re-use or re-cycle it for its production activities.

The majority of waste flows take place within the economic system, from the generator (any production and consumption activity) to the several waste management activities and between the latter. Even the disposals of treated waste on landfill sites may be regarded as a flow within the economic system as long as landfill sites are regarded as human made assets and hence part of the waste management. The residual flows from waste management operations (i.e. economy) to the environment are usually not considered to be waste but emissions to air, soil and water.

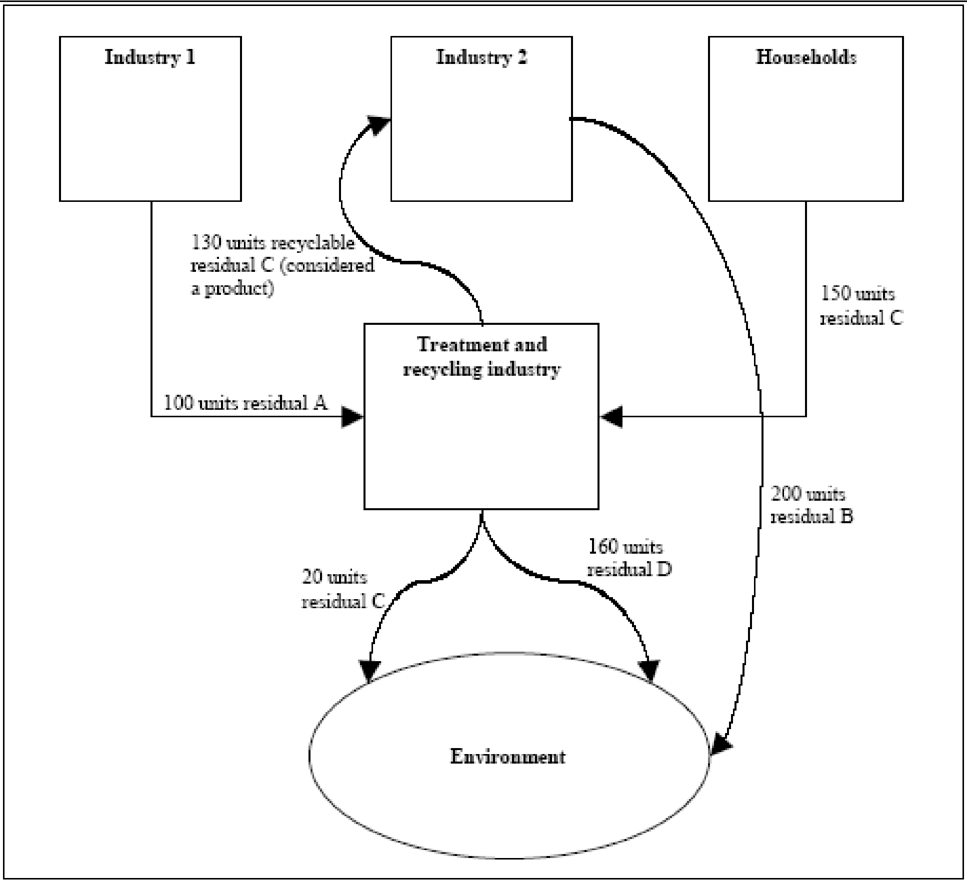
Generally, waste is defined as materials that are not prime products (i.e. products made for the markets) for which the generator has no further use for own purposes of production, transformation, or consumption, and which he wants to dispose of. The website of the European Topic Centre on Resource and Waste Management provides a list of common used terms in conjunction with waste management widely based on legal definitions: http://waste.eionet.europa.eu/definitions.

The ambiguous character of waste (residual or product?) requires some clear rules with regards to its treatment in SNA compatible accounts such as environmentally extended SUT or SIOT schemes as envisaged in the EXIOPOL database. Here, the SEEA 2003 may give some orientation. (see further SEEA 2003; 3.38, paragraphs 3.46-3.64; Chap 2.B p. 28-34; Chap 3B p. 76-87)

In general, the SEEA recommends treating waste as a residual flow. The SEEA 2003 uses the term 'residual' as a single word to cover all solid, liquid, and gaseous wastes and defines it as "incidental and undesired outputs from the economy which generally have no economic value and may be recycled, stored within the economy or discharged into the environment" (SEEA 2003; 2.31). "Scrap which is sold for reprocessing is not classified as a residual but as product. However, some residuals, such as paper and glass products, are recycled without payment to the disposer. This amount is shown as demand by producers for residuals. The amount of waste put into landfill sites is shown as demand by capital for residuals" (SEEA 2003, 2.40). Residuals recycled or reused at the place of generation are excluded (SEEA 2003, Annex 5).

Landfill sites are hence treated as a part of the economy. "The approach adopted in the SEEA is to say that the operation of managed landfill sites is a productive activity; the landfill sites themselves are treated as a sort of physical capital formation" (SEEA 2003; 3.49). Nevertheless, the SEEA also discusses an alternative treatment option where landfill sites are treated as part of the environment (SEEA 2003; paragraph 3.69).

One important conceptual issue is the distinction between gross residual flows and net residual flows; which is of particular importance in the case of waste (see SEEA 2003; paragraphs 3.55-3.64). "Gross residual flows refer to the quantity of residuals generated by all units in the national economy during an accounting period (including leakages from managed landfill sites). Net residual flows refer to the quantity of residuals that is ultimately rejected into the environment (or into a landfill site) following any recycling/re-use or predisposal treatment" (SEEA 2003; 3.55).



Source: SEEA 2003; p 80

Figure 4: Residual flows in a simplified system

In the example given in Figure 4 above, the *gross* residual flows sum up to:

100 units A + 200 units B + (20 +150) units C + 160 units D = 630 units

On the other hand, the *net* residual flows sum up to:

200 units B + 20 units C + 160 units D = 380 units

Clearly, there is an element of double counting: Therefore, a double-entry accounting of waste residuals (in a kind of SUT way) constitutes the most transparent treatment. The Japanese Waste Input-Output model constitutes an interesting proposal to integrate waste flows into an IO framework (Nakamura and Kondo 2002; Takase et al. 2005).

2.6.1 General presentation of waste data availability

Internationally harmonised waste statistics are rare and worldwide waste statistics do not exist.

The OECD together with Eurostat used to collect and publish waste data via their Joint Questionnaire from OECD and EU countries on a voluntary basis. These waste data are rather incomplete and hardly comparable across countries. The definitions of wastes and the surveying methods used vary from country to country. In addition, these waste statistics are incomplete as far as coverage of waste categories, origins (i.e. generators of waste), and treatment types are concerned.

In view of the poor waste statistics, the EU has adopted the Waste Statistic Regulation (EC 2150/2002) in order to establish a harmonised framework for the production of Community statistics on the generation, recovery and disposal of waste. Following the implementation of this regulation, Eurostat has collected and published data for the reporting year 2004. Two data sets are available at Eurostat's online database:

- *Generation of waste*: waste category by industry/household

  48 categories of waste (as laid down in revised Annex I, Section 2 to Waste Statistics Regulation EC 574/2004 = EWC-Stat version 3) by 19 industries and households (as laid down in Annex I, Section 8)

- *Treatment of waste*: waste category by treatment type

The country coverage comprises 31 countries: EU27 + Croatia, Turkey, Iceland, Norway.

A brief and preliminary assessment of these new data reveals that the data quality seems rather critical. Ideally, the total of waste generated should equal the total of waste treated. This, however, is not the case. The reporting countries seem to have difficulties in linking their specific national waste statistic classifications to the new European structures. Many items of the European waste statistics framework need to be estimated by countries whereby different methods are applied due to varying availability of primary data in the respective countries (surveys etc.). Given that this data has been collected for the first time, it is expected that data quality will improve in future.

2.6.2 Problems for use and transformation of Eurostat waste data to EXIOPOL data base

In the following, the two Eurostat waste data sets as derivable from the Waste Statistics Regulation are discussed with regards to their feasibility to transform to the EXIOPOL database.

2.6.2.1 Generation of waste: waste categories by economic activities and households

In this waste data set the classification of economic activities is derived from NACE Rev.1. It comprises 19 items (see Table 7)

Table 7: Classification of economic activities for data set "Waste Generation"

Item No	NACE REV1.1 Code	Description
1	A	Agriculture, hunting and forestry
2	B	Fishing
3	C	Mining and quarrying
4	DA	Manufacture of food products, beverages and tobacco
5	DB+DC	Manufacture of textiles and textile products + Manufacture of leather and leather products
6	DD	Manufacture of wood and wood products
7	DE	Manufacture of pulp, paper and paper products; publishing and printing
8	DF	Manufacture of coke, refined petroleum products and nuclear fuel
9	DG+DH	Manufacture of chemicals, chemical products, man-made fibres + Manufacture of rubber and plastic products
10	DI	Manufacture of other non-metallic mineral products
11	DJ	Manufacture of basic metals and fabricated metal products
12	DK+DL+DM	Manufacture of machinery and equipment + Manufacture of electrical and optical equipment + Manufacture of transport equipment
13	DN Excluded 37	Manufacturing n.e.c.
14	E	Electricity, gas, steam and hot water and water supply
15	F	Construction
16	G — Q Excluded 90 and 51.57	Services activities: Wholesale and retail trade; Repair of motor vehicles, motor cycles and personal and household goods + Hotels and Restaurants + Transports, storage and communications + Financial intermediation + Real estate, renting and business activities + Public administration, defence and compulsory social security + Education + Health and Social work + Other community, social and personal activities + Activities of households + Extra-territorial organisations and bodies
17	37	Recycling
18	51.57	Wholesale of waste and scrap
19	90	Sewage and refuse disposal, sanitation and similar activities

Source: Annex I Section 8 of the Waste Statistics Regulation (EC) No 2150/2002

Evidently, this list is not fully compatible with the envisaged level of breakdown by at least 60 NACE-2-digits. Hence, one has to develop estimation methods to spread waste generation data to the full list of 60 NACE-2-digit divisions.

The waste generated is further classified into the following 48 waste categories (see Table 8).

Table 8: Classification of economic activities for data set "Waste Generation"

Aggregates list			
	EWC-Stat/Version 3		
Item No	Code	Description	Hazardous/Non-hazardous waste
1	01.1	Spent solvents	Hazardous
2	01.2	Acid, alkaline or saline wastes	Non-hazardous
3	01.2	Acid, alkaline or saline wastes	Hazardous
4	01.3	Used oils	Hazardous
5	01.4	Spent chemical catalysts	Non-hazardous
6	01.4	Spent chemical catalysts	Hazardous
7	02	Chemical preparation wastes	Non-hazardous
8	02	Chemical preparation wastes	Hazardous
9	03.1	Chemical deposits and residues	Non-hazardous
10	03.1	Chemical deposits and residues	Hazardous
11	03.2	Industrial effluent sludges	Non-hazardous
12	03.2	Industrial effluent sludges	Hazardous
13	05	Health care and biological wastes	Non-hazardous
14	05	Health care and biological wastes	Hazardous
15	06	Metallic wastes	Non-hazardous
16	06	Metallic wastes	Hazardous
17	07.1	Glass wastes	Non-hazardous
18	07.1	Glass wastes	Hazardous
19	07.2	Paper and cardboard wastes	Non-hazardous
20	07.3	Rubber wastes	Non-hazardous
21	07.4	Plastic wastes	Non-hazardous
22	07.5	Wood wastes	Non-hazardous
23	07.5	Wood wastes	Hazardous
24	07.6	Textile wastes	Non-hazardous
25	07.7	Waste containing PCB	Hazardous
26	08	Discarded equipment	Non-hazardous
27	08	Discarded equipment	Hazardous
28	08.1	Discarded vehicles	Non-hazardous
29	08.1	Discarded vehicles	Hazardous
30	08.41	Batteries and accumulators wastes	Non-hazardous
31	08.41	Batteries and accumulators wastes	Hazardous
32	09	Animal and vegetal wastes (excluding animal waste of food preparation and products; and excluding animal faeces, urine and manure)	Non-hazardous
33	09.11	Animal waste of food preparation and products	Non-hazardous
34	09.3	Animal faeces, urine and manure	Non-hazardous
35	10.1	Household and similar wastes	Non-hazardous
36	10.2	Mixed and undifferentiated materials	Non-hazardous
37	10.2	Mixed and undifferentiated materials	Hazardous
38	10.3	Sorting residues	Non-hazardous
39	10.3	Sorting residues	Hazardous
40	11	Common sludges (excluding dredging spoils)	Non-hazardous
41	11.3	Dredging spoils	Non-hazardous
42	12.1 + 12.2 + 12.3 + 12.5	Mineral wastes (excluding combustion wastes, contaminated soils and polluted dredging spoils)	Non-hazardous
43	12.1 + 12.2 + 12.3 + 12.5	Mineral wastes (excluding combustion wastes, contaminated soils and polluted dredging spoils)	Hazardous
44	12.4	Combustion wastes	Non-hazardous
45	12.4	Combustion wastes	Hazardous
46	12.6	Contaminated soils and polluted dredging spoils	Hazardous
47	13	Solidified, stabilised or vitrified wastes	Non-hazardous
48	13	Solidified, stabilised or vitrified wastes	Hazardous'

Source: Regulation (EC) No 574/2004 amending the Waste Statistic Regulation

Notably, this list of waste categories is not the same as used for the waste treatment data sets (see next section).

2.6.2.2 Treatment of waste: waste categories by treatment type

Waste treatment refers to all recovery and disposal operations/facilities which belong to or are part of the economic activities according to the groupings of NACE REV 1. Facilities, whose waste treatment activities are limited to the recycling of waste on the site where the waste was generated, are not covered by this statistics.

The Waste Statistics Regulation defines the following treatment types (see Table 9).

Table 9: Classification of waste treatment types for data set "Treatment of Waste"

Item No	Code	Types of recovery and disposal operations
		Incineration
1	R1	Use principally as a fuel or other means to generate energy
2	D10	Incineration on land
		Operations which may lead to recovery (excluding energy recovery)
3	R2 +	Solvent reclamation/regeneration
	R3 +	Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes)
	R4 +	Recycling/reclamation of metals and metal compounds
	R5 +	Recycling/reclamation of other inorganic materials
	R6 +	Regeneration of acids or bases
	R7 +	Recovery of components used for pollution abatement
	R8 +	Recovery of components from catalysts
	R9 +	Oil refining or other reuses of oil
	R10 +	Land treatment resulting in benefit to agriculture or ecological improvement
	R11	Use of wastes obtained from any of the operations numbered R1 to R10

Item No	Code	Types of recovery and disposal operations
		Disposal operations
4	D1 +	Deposit into or onto land (e.g. landfill etc.)
	D3 +	Deep injection (e.g. injection of pumpable discards into wells, salt domes or naturally occurring repositories etc.)
	D4 +	Surface impoundment (e.g. placement of liquid or sludge discards into pits, pounds or lagoons etc.)
	D5 +	Special engineered landfill (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment etc.)
	D12	Permanent storage (e.g. emplacement of containers in a mine etc.)
5	D2 +	Land treatment (e.g. biodegradation of liquid or sludgy discards in soils etc.)
	D6 +	Release into a water body except seas/oceans
	D7	Release into seas/oceans including sea-bed insertion

Source: Annex II Section 8 of Waste Statistics Regulation

Eurostat publishes results only by the 5 aggregated treatment types, namely

(1) Incineration

(2) Energy recovery

(3) Recovery

(4) Deposit onto or into land

(5) Land treatment and release into water bodies

The second dimension for this "Treatment of Waste" dataset is waste categories. As mentioned earlier, the waste categories used to report waste treatment amounts is not the same as for the waste generation. In addition, different listings of waste categories are used for the several treatment types:

- for incineration (type (1) and (2)) 12 waste categories are used;
- for operations which may lead to recovery (without energy recovery) (type (3)) 18 waste categories are used;
- for disposal operations (type (4) and (5)) 15 waste categories are used.

In its online-database, Eurostat has apparently merged these different listings to one single list of waste categories (comprising some 50 items) for the waste treatment data set.

2.6.2.3 Transformation-problems summarised

In conclusion, the following problems can be summarised with regards to transformation of Waste Statistics Regulation data to the EXIOPOL database/framework:

1) The classification of 19 economic activities as applied in the waste generation data set is insufficient and one would need an extrapolation/spreading to 60 NACE-2-digit levels, at least.

2) All in all, it is quite confusing that 4 different listings of waste categories are applied. For arranging waste flows in the EXIOPOL database/framework, a single common list/classification of waste categories is needed. (We may find a common denominator of all 4 listings).

3) Only waste output flows from economic activities (Waste Generation) is provided. However, there might be also waste input flows to economic activities (e.g. steel scrap to iron & steel industry).

4) The Waste Statistic Regulation data sets only provide information on waste input flows to treatment types. However, it is not known which economic activities (i.e. NACE divisions) are operating these facilities. Evidently, many of those treatments facilities might be operated by NACE 37, but not all. Hence, we need to find a way/method to allocate the waste treatment to NACE divisions. The Japanese Waste-Input-Output table offers a potential solution. The waste treatment activities are pulled out of the monetary IOT and presented as additional/separate columns and rows.

2.6.3 Key choices with regards to waste data

Only European waste flows to be considered in EXIOPOL:

Due to the lack of internationally harmonised waste data one may decide to only consider European waste accounts (for which Eurostat provide some data) in the EXIOPOL framework. This is reasonable insofar as waste flows and waste management can be perceived as a rather regional issue.

Poor quality of European data:

The current data – collected via the very first survey under the new Waste Statistics Regulation – seems to be of poor quality. In the short-term, this data may be used as a kind of "dummy" in the EXIOPOL database. It might be replaced by up-dated and hopefully improved data at a later stage.

Transformation problems: insufficient industry breakdown and confusing listings for waste categories

These two transformation problems are due to the format/structure of the Waste Statistics Regulation data sets. The available industry breakdown for waste generation might be extrapolated to 60 industries using certain auxiliary variables (e.g. employment). The different listings of waste categories can be merged to a "common denominator" implying that the number of categories will be limited.

2.7 Excurse: Ecological Footprint

At the Cluster-III kick-off meeting in Milan it was decided to consider the Ecological Footprint (EF) in the environmental extensions of the EXIOPOL IO framework. Initially, the idea was to link the Ecological Footprint data somehow to land and to collect at least those land use data which are related to the composition of Ecological Footprint accounts, namely land providing renewable resources and assimilating emissions. Basically, this is agricultural land and forestry.

However, it seems much more logical and practical to link the EF to mass flows, namely biomass material inputs (see section 2.1) and CO2-emissions to air (see section 2.4). A closer look at the EF accounting methodology reveals that the points of departure for calculation are those two material flows.

2.7.1 Overview: data required to calculate/derive Ecological Footprint accounts

Although the Ecological Footprint is expressed in virtual 'global hectares', its major calculation basis are, however, mass flows. The latter are translated into 'global hectares'.

The following six components are part of the EF account (see Figure 5):

- Crops (t)
- Animal products (t)
- Fish (t)
- Forest products (t)
- Build-up area (ha)
- Fossil fuel emissions (t CO_2) or fossil energy (ktoe)

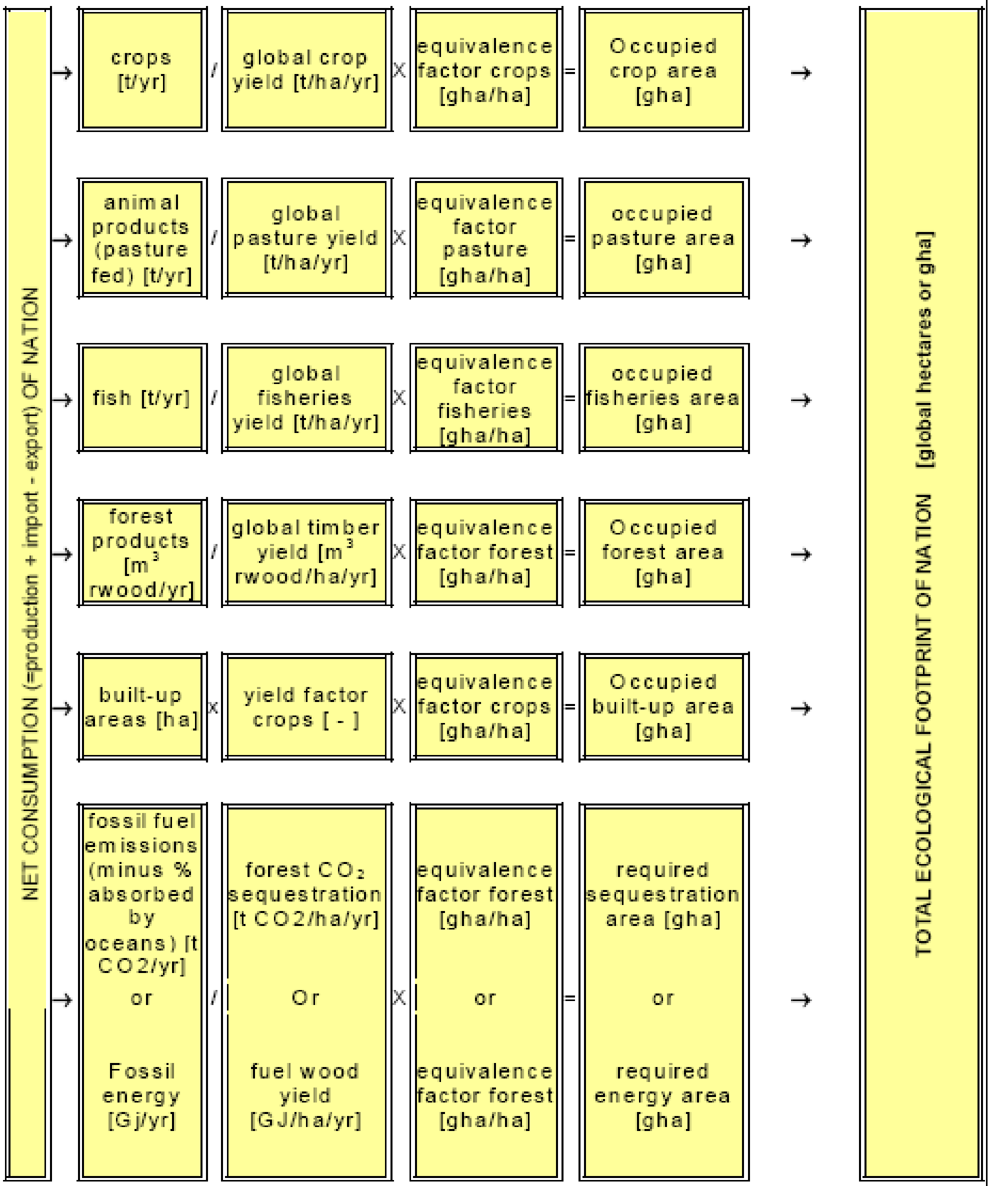
Apart from the category of "built-up land", which is measured in hectares, the sub-items consumed are determined in tonnes. As mentioned in section 2.2, international harmonised data on built-up area are not available. They seem almost neglectable since the only make up a very small share of the EF.

The components 1 to 4 are part of the material inputs as discussed in section 2.1. CO_2-emissions are discussed in section 2.4.

The EF concept uses the unit "global hectare" (gha) as the final unit of calculation. Several calculation steps are needed to derive from tonnes to gha.

A) From mass volumes to real hectare: this can be done be dividing the mass by yield (t/ha) or by simply using the area from FAOSTAT data;

B) From real area to 'global hectares': a "global hectare" is a hectare with average global bio-productivity; as different types of land (e.g. agricultural or forestry land) have different productivities compared to the global average, so-called "equivalence factors" are applied to transform areas of different land use types into the unit "global hectare".



Source: Wackernagel et al. 2005

Figure 5: Components and calculation steps in Ecological Footprint accounts

The coefficients needed to make the transformations from tonnes to global hectares can be taken from the literature or the EF community may be contacted directly. It has to be noted that the data sources and conversion factors used in EF accounts are not always transparent Although short descriptions of the EF methodology are available on the website of the Global Footprint Network, detailed factors for the transformation of quantities into land (and water) area equivalents are only listed in the National Footprint

Accounts, which have to be purchased. However, the Global Footprint Network also underlines that one of the key priorities for further improvement and standardisation of the methodology is to provide a detailed guidance manual for EF calculations, which should increase the transparency of the different calculation steps (Kitzes et al., 2007).

In the following, we briefly describe possibilities and problems related to the derivation of the different components of the EF:

a) Crops – crop land

The production volumes of primary crops are recorded under material inputs (biomass from agriculture) and can be downloaded from FAOSTAT. For the very same crops FOASTAT also provides the area. Note, that the list of primary crops also includes several fodder crops which have to be deducted here and considered under the following item.

b) Animal products (pasture fed) – pasture land

We find that biomass from grazing (an item determined in materials inputs) and fodder crops represent the adequate corresponding product volume. These constitute the 'primary' product that are further processed to e.g. cows and all kind of diary products. The 'real' land areas corresponding to these mass flows are 'permanent meadows and pastures' and arable land for fodder crops as reported by FAOSTAT.

c) Fish – fisheries land

In the current EF calculation method, fish consumption is assigned to productive water areas. The yield of a given water area (in ha) is estimated taking into account the maximum net primary production in this area (disaggregated by 26 shelf zones), the trophic level of the catched species and discard rates.

What we know in EXIOPOL is the tonnages of fish landed by resident units (part of material inputs – biomass from fisheries). This figure could be multiplied by the respective yield factor as it is used in the EF accounts. However, these yield factors are not publicly available and would need to be purchased as part of the National Footprint Accounts of the different countries. Unclear is which factor to be used. [Comment: We might consider to skip this calculation of fish production (in tons) into water area equivalents, as the applied factors are of insufficient reliability.]

d) Forest products – forestry land

The related material flow is biomass from forestry. The total of forestry biomass harvested is equivalent to the 'real' forest land area as reported in FAOSTAT. Further detailing into single wood products seems difficult since no specific yields and areas are known.

e) Built-up area

As mentioned earlier, no international data is available on built-up area. One may use the data as employed by ET accounts, which use different data sources, such as the Global Agroecological Zones (AGEZ) model by IIASA and FAO and CORINE land cover data for Europe. Even if we manage to find data on built-up land, a serious problem remains: how can we allocate to 60 NACE industries and private households? [Comment: we would suggest to skip this category]

f) CO2-emissions from fossil fuels – CO2-sequestration forest land

Here, we only know the CO2-emissions from fossil fuels by industries/products. In order to translate this number into an area equivalent, we would need a general factor/coefficient expressing how much forest land is necessary to absorb 1 tonne of CO2. In the National Footprint Accounts, the area equivalent is calculated by first subtracting the amount absorbed by oceans (assumed to be one third of total emission) and then dividing the remaining emissions by a sequestration factor. This factor is derived from IPPC reports and is set at 1 ton of carbon per hectare and year.

2.7.2 Transfer issues

An important feature of the original Ecological Footprint accounts is that its start of departure is 'net consumption' volumes of the single items. Consumption is derived from adding imports to domestic production and deducting export. This is done on a commodity by commodity basis.

Relating natural resource items to consumption does not make sense in an environmentally extended Input-Output framework such as the EXIOPOL database. In the EXIOPOL framework environmental extensions need to be linked to the production activities and the re-attribution to consumption is done in a later analytical step. In the multi-regional IO framework it will be able to specify the origin of the EF re-attributed to the consumption of a certain good in a certain country (e.g. how much Brazilian EF is 'embodied' in the Dutch consumption of cheese?) which is not the case with the traditional EF.

The allocation of the single footprint items to industries is the same as for the underpinning biomass materials and CO_2-emissions.

2.7.3 Key choices with regards to considering EF accounts

Link to Ecological Footprint accounts

The Ecological Footprint (EF) operates with 'virtual' land use units (global hectares). Data-wise EF accounts are hence not based on and linkable to 'real' land use data. Moreover, the single EF items are linked to material biomass inputs and CO_2-emissions which are transformed into global hectares in a two-step calculation.

3 Key choices summarised

SIOT versus SUT framework

From an environmental extension point of view, it might be favourable to use a SUT scheme. This offers the flexibility to assign environmental extension to industries and/or products.

For some environmental extensions the basic data are rather related to products than to industries. This is particularly the case for residuals (i.e. air emissions, waste). If we are to generate our own NAMEA-type data we will use the CRF categories. Those are rather product related than industry related. For instance, emissions from certain power generation technologies can clearly be assigned to electricity; but it remains unclear whether this electricity product is produced in the electricity industry (NACE 40.1) or whether it is produced as a secondary product, let's say, in the manufacturing of metals. In a SUT scheme we would be able to distribute electricity related emissions to all those industries producing electricity.

Level of disaggregation

The detail of material, land and water inputs stands in a certain contradiction to the coarse aggregation level of industries.

The natural resource inputs (i.e. material inputs, land, and water) have a common feature: they are extracted/harvested/used by a limited number of industries, namely agriculture & forestry and mining. Using 60 by 60 IO tables implies that those environmental extensions are assigned to about only 3-5 NACE divisions. On the other hand, the natural resource input data are of great detail (could easily be 100-200 sub-items). For instance the potential 100 different biomass material inputs are assigned to one industry only and subsequently re-attributed to final demand (via the 60 x 60 Leontief matrix) in a very imprecise way (e.g. cereals will end up in final use of leather products). Another example: the different metal raw-materials (iron, aluminium, copper etc.) would only be assigned to one mining sector.

From this viewpoint it would be better to have a detailed disaggregation of industries; e.g. as indicated in the DoW.

Given the case that the IO tables will not be detailed, there might be an alternative option of assigning the natural resource inputs to industries – as proposed by Karl Schoer from the German Statistical Office (Schoer 2006). Here, the resource input is not assigned to the industry that is actually extracting/harvesting the respective material input. Moreover, they try to assign raw materials to the industries processing the respective raw material on the first or second stage. For instance, iron ore is not assigned to the ore mining industry (NACE 13) but to the manufacture of basic iron and steel (NACE 27.1). However, this "Schoer-approach" will require considerable additional statistical information and one may have to detail again certain manufacturing industries – the NACE 2-digit level might be still too coarse.

How to treat waste?

If we should decide to follow the Japanese Waste-Input-Output approach, we would need to detail the waste treatment industries (i.e. NACE 37 and 90) and extend the 60 by 60 transformation matrix by 5 treatment types. Actually, we would end up with a hybrid transformation matrix.

Final decision: which environmental extension shall be included with which detail?

In the coming pilot phase (until month 12) will be used to test the different data sources and estimation methods for 2-4 countries. Where the ambition is unambiguously to cover some 30-45 substances that cover the most important environmental themes, and also allow for a meaningful calculation of externalities, and to give a fundamentally more complete emission overview than the many earlier EE I-O studies mainly concentrating on a few energy related emissions, the definite final list of environmental extensions will be presented after the testing phase.

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Annex – overview

Annex 1	3-digit classification for material flows (domestic extraction) as applied in Eurostat MFA-questionnaire 2007	section 2.1
Annex 2	Comparison of Eurostat and IEA formats for Gas/Diesel Oil balance	section 2.4

Annex 1: 3-digit classification for material flows (domestic extraction) as applied in Eurostat MFA-questionnaire 2007

A.1 Biomass

- A.1.1 Primary crops
  - A.1.1.1 Cereals
  - A.1.1.2 Roots, tubers
  - A.1.1.3 Sugar crops
  - A.1.1.4 Pulses
  - A.1.1.5 Nuts
  - A.1.1.6 Oil bearing crops
  - A.1.1.7 Vegetables
  - A.1.1.8 Fruits
  - A.1.1.9 Fibres
  - A.1.1.10 Other crops (Spices Stimulant crops, Tobacco, Rubber and other crops)
- A.1.2 Crop residues (used)
  - A.1.2.1 Straw
  - A.1.2.2 Other crop residues (sugar and fodder beet leaves, other)
- A.1.3 Fodder crops incl grassland harvest
  - A.1.3.1 Fodder crops
  - A.1.3.2 Biomass harvested from grassland
- A.1.4 Grazed biomass
- A.1.5 Wood
  - A.1.5.1 Timber (Industrial roundwood)
  - A.1.5.2 Wood fuel and other extraction
- A.1.6 Fish capture, crustaceans, molluscs and aquatic invertebrates
- A.1.7 Hunting and gathering

A.2 Metal ores (gross ores)

- A.2.1 Iron ores
- A.2.2 Non-ferrous metal ores
  - *A.2.2.1.a Copper ores - gross ore (t)*
  - *A.2.2.1.b Copper ores - metal content (t)*
  - *A.2.2.2.a Nickel ores - gross ore (t)*
  - *A.2.2.2.b Nickel ores - metal content (t)*
  - *A.2.2.3.a Lead ores - gross ore (t)*
  - *A.2.2.3.b Lead ores - metal content (t)*
  - *A.2.2.4.a Zinc ores - gross ore (t)*
  - *A.2.2.4.b Zinc ores - metal content (t)*
  - *A.2.2.5.a Tin ores - gross ore (t)*
  - *A.2.2.5.b Tin ores - metal content (t)*
  - *A.2.2.6.a Gold, silver, platinum and other precious metal ores - gross ore (t)*
  - *A.2.2.6.b Gold, silver, platinum and other precious metal ores - metal content (t)*
  - *A.2.2.7.a Bauxite and other aluminium ores - gross ore (t)*
  - *A.2.2.7.b Bauxite and other aluminium ores - metal content (t)*
  - *A.2.2.8.a Uranium and thorium ores - gross ore (t)*
  - *A.2.2.8.b Uranium and thorium ores - metal content (t)*
  - *A.2.2.9.a Other metal ores - gross ore (t)*
  - *A.2.2.9.b Other metal ores - metal content (t)*

A.3 Non metalic minerals

- A.3.1 Ornamental or building stone
- A.3.2 Limestone, gypsum, chalk, and dolomite
- A.3.3 Slate
- A.3.4 Gravel and sand
- A.3.5 Clays and kaolin
- A.3.6 Chemical and fertilizer minerals
- A.3.7 Salt
- A.3.8 Other mining and quarrying products n.e.c.
- A.3.9 Excavated soil, only if used (e.g for construction work)

A.4 Fossil energy carriers

- A.4.1 Brown coal incl. oil shale and tar sands
- A.4.2 Hard coal
- A.4.3 Petroleum
- A.4.4 Natural gas
- A.4.5 Peat

Annex 2: Comparison of Eurostat and IEA formats for Gas/Diesel Oil balance

FRANCE 1999 — GAS/DIESEL OIL — kilotonnes

EUROSTAT format

Primary production	-
Recovered products	-
Imports	11 668
Stock change	1 213
Exports	-2 230
Bunkers	-419
Gross inland consumption	10 232
Transformation input	48
Public thermal power stations	18
Autoprod. thermal power stations	23
Nuclear power stations	-
Patent fuel and briquetting plants	-
Coke-oven plants	-
Blast-furnace plants	-
Gas works	-
Refineries	-
District heating plants	
Transformation output	32 621
Public thermal power stations	-
Autoprod. thermal power stations	
Nuclear power stations	-
Patent fuel and briquetting plants	-
Coke-oven plants	-
Blast-furnace plants	-
Gas works	-
Refineries	32 621
District heating plants	-
Exchanges and transfers, returns	-865
Interproduct transfers	0
Products transferred	-529
Returns from petrochem. industry	-336
Consumption of the energy branch	4
Distribution losses	-
Available for final consumption	41 936
Final non-energy consumption	1 383
Chemical industry	1 383
Other sectors	-
Final energy consumption	42 818
Industry	1 092
Iron & steel industry	*35*
Non-ferrous metal industry	*15*
Chemical industry	*0*
Glass, pottery & building mat. industry	*122*
Ore-extraction industry	*1*
Food, drink & tobacco industry	*110*
Textile, leather & clothing industry	*38*
Paper and printing	*14*
Engineering & other metal industry	*200*
Other industries	*557*
Transport	26 801
Railways	*368*
Road transport	*25 948*
Air transport	-
Inland navigation	*485*
Households, commerce, pub. auth, etc.	14 925
Households	*8 442*
Agriculture	*2 026*
Statistical difference	-2 265

IEA format

Production	32 621
From other sources	-
Imports	11 668
Exports	-2 230
Intl marine bunkers	-419
Stock change	1 213
DOMESTIC SUPPLY	42 853
Transfers	-529
Statistical difference	2 265
TRANSFORMATION	384
Electricity plants	41
CHP plants	-
Heat plants	-
Blast furnaces/gas works	-
Coke/pat. fuel/BKB plants	-
Petroleum refineries	-
Petrochemical industry	336
Liquefaction plants	-
Other transformation sector	7
ENERGY SECTOR	4
Coal mines	-
Oil and gas extraction	-
Petroleum refineries	4
Electricity and heat plants	-
Pumped storage	-
Other energy sector	-
Distribution losses	-
FINAL CONSUMPTION	44 201
INDUSTRY SECTOR	2 475
Iron and steel	35
Chemical and petrochemical	1 383
of which: Feedstock	*1 383*
Non-ferrous metals	15
Non-metallic minerals	122
Transport equipment	48
Machinery	152
Mining and quarrying	1
Food and tobacco	110
Paper, pulp and print	14
Wood and wood products	-
Construction	409
Textile and leather	38
Non-specified	148
TRANSPORT	26 801
International civil aviation	-
Domestic air	-
Road	25 948
Rail	368
Pipeline transport	-
Internal navigation	485
Non-specified	-
OTHER SECTORS	14 925
Agriculture	2 026
Commerce and pub. services	4 450
Residential	8 442
Non-specified	7
NON-ENERGY USE	-
Industry/transformation/energy	-
Transport	-
Other sectors	-