

## Final Publishable Summary Report

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CREEA is a Collaborative project funded by the EU's  
Seventh Framework Program – Theme ENV.2010.4.2.2-1  
Grant agreement no: 265134

<b>Deliverable number:</b>	-
<b>Revision number:</b>	
<b>Date of current draft:</b>	
<b>Due date of deliverable:</b>	
<b>Actual submission date:</b>	
<b>Dissemination level:</b>	PU

## CREEA

Compiling and Refining Environmental and Economic Accounts

Funded by the EU's Seventh Framework Program – Theme ENV.2010.4.2.2-1

Collaborative project

Grant agreement no: 265134

Start date of the project: 1 April 2011, Duration: 36 Months

### About CREEA

The main goal of CREEA is to refine and elaborate economic and environmental accounting principles as discussed in the London Group and consolidated in the future SEEA 2012, to test them in practical data gathering, to troubleshoot and refine approaches, and show added value of having such harmonized data available via case studies. This will be done in priority areas mentioned in the call, i.e. waste and resources, water, forest and climate change / Kyoto accounting. In this, the project will include work and experiences from major previous projects focused on developing harmonized data sets for integrated economic and environmental accounting (most notably EXIOPOL, FORWAST and a series of EUROSTAT projects in Environmental Accounting). Most data gathered in CREEA will be consolidated in the form of Environmentally Extended Supply and Use tables (EE SUT) and update and expand the EXIOPOL database. In this way, CREEA will produce a global Multi-Regional EE SUT with a unique detail of 130 sectors and products, 30 emissions, 80 resources, and 43 countries plus a rest of world. A unique contribution of CREEA is that also SUT in physical terms will be created. Partners are:

1. Nederlandse Organisatie Voor Toegepast Natuurwetenschappelijk Onderzoek (TNO), Netherlands (co-ordinator)
2. JRC -Joint Research Centre- European Commission (DG JRC IPTS), Belgium /Spain
3. Universiteit Leiden (Unileiden), Netherlands
4. Centraal Bureau voor de Statistiek (CBS), Netherlands
5. Norges Teknisk-Naturvitenskapelige Universitet (NTNU), Norway
6. Statistiska Centralbyran (SCB), Sweden
7. Universiteit Twente (TU Twente), Netherlands
8. Eidgenössische Technische Hochschule Zürich (ETH) Switzerland
9. 2.-0 LCA Consultants Aps (2.-0 LCA), Denmark
10. Wuppertal Institut Fur Klima, Umwelt, Energie Gmbh. (WI), Germany
11. SERI - Nachhaltigkeitsforschungs Und -Kommunikations Gmbh (SERI) Austria
12. European Forest Institute (EFI), Finland / Spain
13. Wirtschaftsuniversität Wien, Vienna / Austria

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# 1 Executive Summary

CREEA was a three-year collaborative project funded the EC's 7<sup>th</sup> Framework Programme. The main goal of CREEA was:

- to refine and elaborate economic and environmental accounting principles as discussed in the London Group and consolidated in the System of Economic and Environmental Accounts (SEEA) 2012;
- to test them in practical data gathering;
- to troubleshoot and refine approaches;
- to show added value of having such harmonized data available via case studies.

The project was divided in 4 main elements, structured as follows:

1. Inception and reflection (WP2)
2. Method refining, testing and inventories (WP3-6).
  - a. WP3 (Water accounts): Refined and tested SEEA and relevant water accounting parts of SEEA2012; developed Valuation methods for water; developed water quality accounts for physical, chemical and thermal pollution; and produced a data asset for integration into EXIOBASE
  - b. WP4 (Waste and material flow accounts): Harmonized terminology and classification of waste and waste products, integrated waste and MFA accounts in the form of a data set for EXIOBASE, and compiled standardized waste tables for a test country (Netherlands)
  - c. WP5 (Forestry accounts): Revised the proposed SEEA 2012 methodology for forests, developed procedures for integrating forest data into SEEA 2012, and tested methodology for selected countries
  - d. WP6 (Climate change issues): Developed consistent energy and air emission accounts (including a data set for EXIOBASE), developed land use cover change accounts, investigated emission allowances and trading accounts and analysed the potential for inclusion of other economic responses in SEEA
3. Integration and case studies (WP7, 8):
  - a. WP7: Integration into the EXIOBASE database
  - b. WP8: Executing policy case studies
4. Management and external integration (WP1, 9).

In line with SEEA 2012, where possible data were organised in the form of a Multi-regional Environmentally Extended Input Output Database, called EXIOBASE. This database now consists of 43 countries, 5 rest of continents, discerning 200 product groups and 160 economic sectors per country including all links via trade between countries, with some 40 emissions, land use, water use and 80 types of resource extractions by sector. The power of this database is exemplified by CREEA's probably most visible deliverable: The Global Resource Footprint of Nations. Using the EXIOBASE, it presents 43 country factsheets encapsulating the carbon, water, land and material footprint of final consumption, plus various global comparative analyses. See <http://creea.eu/index.php/7-project/8-creea-booklet>. Such analyses are essential for virtual all major sustainability policy programs, such as the UN's Green Economy Initiative, Resource-efficiency initiatives, the 10 Year Framework of Programs on Sustainable Consumption and Production, and others.

## 2 Summary description of the project context and the main objectives

### 2.1 Project context

In 1993, the United Nations and other bodies published the System of National Accounts (SNA; UN, 1993). This SNA provides guidance to national statistical institutes (NSIs) of different countries of how to organise their system of national accounts. It goes without saying that this SNA plays a pivotal role in ensuring that key economic parameters such as GNP, labour productivity, etc. are constructed and measured in a harmonized manner. Without the SNA, economic performance of different countries most probably cannot be compared easily.

In 2003, a system of satellite accounts for environmental accounting was proposed, known under the name of System of Environmental and Economic Accounting – in short: SEEA 2003 (UN, 2003). This accounting system gives guidelines for setting up environmental accounts which are compatible with the system of national accounts. From the practice of research and environmental assessment agencies it appears that in many cases the availability of harmonized data sets is still impeding effective monitoring, assessment and priority setting in the field of economic and environment. It concerns here both harmonization of economic accounts with data on environmental topics, as well as harmonization of data available from different countries. The practical implication is that many assessments that overarch single countries still have to be done via dedicated projects that have to spent significant time on data transformation, rather than that they can use harmonized data directly in analyses. On top of this, various issues in environmental accounting are methodologically still amorphous. Methodological and practical complexities and preferences imply that no clear accounting approach could yet have been selected.

One of the answers to these problems is further work on standardisation. A revised and extended SEEA is planned to be published in 2012 (in short: SEEA 2012). The UNCEEA (UN Commission of Experts on Environmental and Economic Accounting) is responsible for this work, with most of the operational work being executed in the so-called 'London Group' (LG), a group of operational experts from statistical offices globally. The London Group has been the main platform for discussing issues to be included in the new SEEA 2012, and most of its work has been finalised by now. This implies that in broad lines guidance is given on important issues around economic and environmental accounting, and that the remaining task is mainly consolidating these findings in a draft SEEA text.

Harmonization and standardization is just one part of the issue, though. It is at least as important that the added value of using SEEA 2012 and gathering practical data is obvious. The information that NSIs in principle could gather is almost limitless; they hence have to set always priorities. The capacity of NSIs has its limits, and also the companies and other societal actors have limited capacity to deliver information via surveys and the like. This implies two things:

- Data gathering must be organised as efficiently as possible, implying that there is a limit to the complexity of methodologies that can be suggested in SEEA 2012;

- The data gathering must be focused on topics of the highest political relevance, and it must be made clear that the data can find easy and practical application in policy making.

In conclusion, the analysis above implies that a project set up along the following lines will make major contributions to SEEA 2012, and above all, its practical implementation. In short, such a program fills in remaining gaps in SEEA 2012, gives guidance into the most effective ways of practical implementation (particularly data gathering), and can build a case showing the added value of practically implementing SEEA 2012.

## 2.2 Project objectives

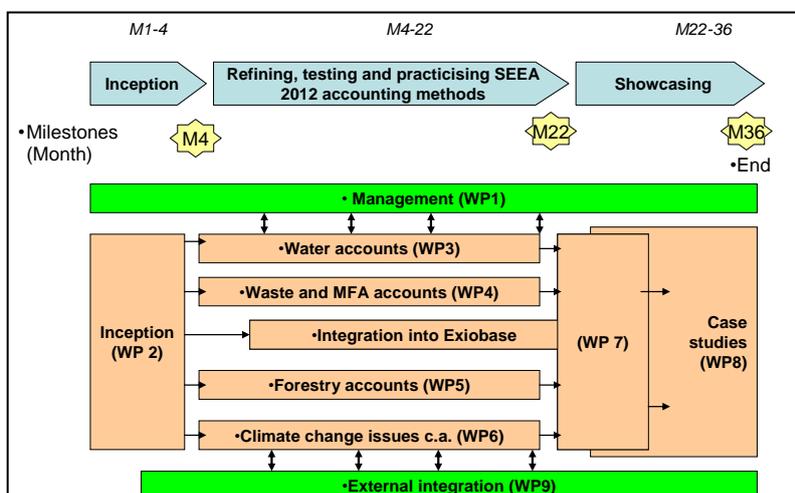
CREEA was a three-year collaborative project funded under EC FP7. The main objectives of CREEA were:

- to refine and elaborate economic and environmental accounting principles as discussed in the London Group and consolidated in the future SEEA 2012;
- to test them in practical data gathering;
- to troubleshoot and refine approaches;
- to integrate data where possible in a harmonized Multi-regional Environmentally Extended Supply and Use / Input Output (MR EE SUT/IOT) and to show added value of having such harmonized data available via case studies.

The project is divided in 4 main elements, structured as follows (see Figure 2.1):

5. Inception and reflection (WP2)
6. Method refining, testing and inventories (WP3-6).
  - a. WP3 (Water accounts)
  - b. WP4 (Waste and material flow accounts)
  - c. WP5 (Forestry accounts)
  - d. WP6 (Climate change issues)
7. Integration and case studies (WP7, 8):
  - a. WP7: Integration into the EXIOBASE database
  - b. WP8: Executing policy case studies
8. Management and external integration (WP1, 9).

Figure 2.1: Project structure



### 2.3 Project concept: MR EE SUT/IOT as leading principle for organizing data

The project uses the concept of Multi-regional Environmentally Extended Supply and Use / Input Output tables to organise the bulk of the data gathered into a harmonized system. SUT and IOT form a central accounting framework for environmental and economic data. This accounting system also forms the conceptual backbone for CREEA (European Communities 1996; compare UN, 1993 and UN et al.,2003).

The supply table shows the supply of goods and services, both domestic and imported, by product and type of supplier in basic prices, while the use table shows the use of goods and services by product and type of use in purchase prices, i.e. as intermediate consumption by industries, final use (consumption, gross capital formation) and exports. The use table also contains the components of the value added by industry, i.e. compensation of employees, other taxes less subsidies on production and gross operating surplus. The use table can be converted to basic prices with the help of valuation matrices reflecting retail, wholesale and taxes/subsidies per product used per industry. If necessary, the SUT can be broken down into a domestic and import (use) and an export (supply) part.

Most analytical applications and models used (e.g. CGE) are based on IOTs rather than SUT. Using various assumptions about technology, IOTs can be derived from the SUT in basic prices. The tables can be of a product by product type or an industry by industry type (see figure 2.2). SUT and IOT can be expanded with satellite accounts to indicate an industry’s resource inputs from and emission outputs to the environment (see figure 2.3)

Figure 2.2: Simplified input-output framework (modified from Rueda-Cantucho et al., 2007)

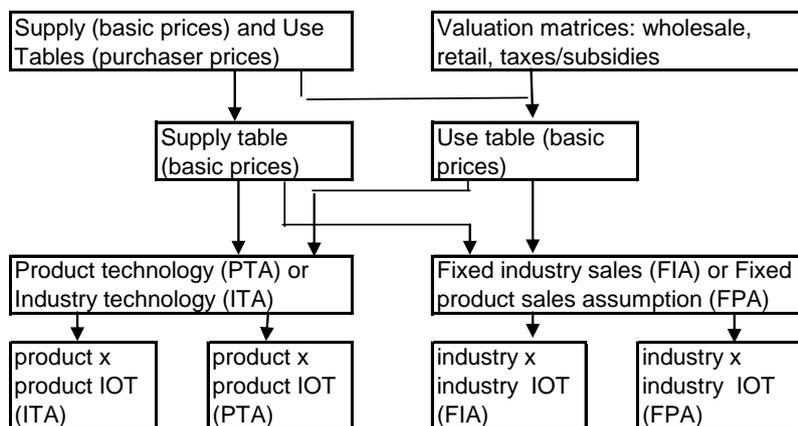


Figure 2.3: Schematic SUT with environmental extensions

	<b>Products</b>	<b>Industries</b>			
<b>Products</b>		Use	Final use	Exports	Use of products
<b>Industries</b>	Make / Supply				Output of industries
	Imports cif	Value added			
	Supply of products	Input of industries			
		Extensions: - Primary Natural Resource input - Emissions output - etc.			

Note that Figure 2.3. shows an EE SUT for a single country. This leads to the problem of how dealing with imports and exports. EE SUT/IOT practitioners often apply a shortcut and assume that imported goods and services are made with the same technology as those produced domestically. This can lead to serious errors. A more comprehensive method would be a truly multi-regional approach, in which different country EE SUT or EE IOT are linked via trade to a multi-regional SUT or IOT with environmental extensions (MR EE SUT or MR EE IOT). Figure 2.4 visualises an MR EE SUT. The EXIOPOL project that is input to CREEA has created a database covering 43 countries, a Rest of World, in 129 sectors/products by country, with 30 emissions, 80 resources, land and water as extensions. CREEA’s ambition was to organize where possible and feasible, data gathered in WP3-6 into a new version of EXIOBASE.

Figure 2.4: Example of a MR EE SUT for 4 countries

		Industries				$Y_{\cdot,A}$	$Y_{\cdot,B}$	$Y_{\cdot,C}$	$Y_{\cdot,D}$	q
<b>Products</b>		$Z_{A,A}$	$Z_{A,B}$	$Z_{A,C}$	$Z_{A,D}$	$Y_{A,A}$	$Y_{A,B}$	$Y_{A,C}$	$Y_{A,D}$	$q_A$
		$Z_{B,A}$	$Z_{B,B}$	$Z_{B,C}$	$Z_{B,D}$	$Y_{B,A}$	$Y_{B,B}$	$Y_{B,C}$	$Y_{B,D}$	$q_B$
		$Z_{C,A}$	$Z_{C,B}$	$Z_{C,C}$	$Z_{C,D}$	$Y_{C,A}$	$Y_{C,B}$	$Y_{C,C}$	$Y_{C,D}$	$q_C$
		$Z_{D,A}$	$Z_{D,B}$	$Z_{D,C}$	$Z_{D,D}$	$Y_{D,A}$	$Y_{D,B}$	$Y_{D,C}$	$Y_{D,D}$	$q_D$
<b>W</b>		$W_A$	$W_B$	$W_C$	$W_D$					
		$g_A$	$g_B$	$g_C$	$g_D$					
<b>C &amp; L</b>		Capital <sub>A</sub>	$C_B$	$C_C$	$C_D$					
		Labor <sub>A</sub>	$L_B$	$L_C$	$L_D$					
<b>Environ Ext</b>		NAMEA <sub>A</sub>	NAMEA <sub>B</sub>	NAMEA <sub>C</sub>	NAMEA <sub>D</sub>					
		Agric <sub>A</sub>	Agric <sub>B</sub>	Agric <sub>C</sub>	Agric <sub>D</sub>					
		Energy <sub>A</sub>	Energy <sub>B</sub>	Energy <sub>C</sub>	Energy <sub>D</sub>					
		Metal <sub>A</sub>	Metal <sub>B</sub>	Metal <sub>C</sub>	Metal <sub>D</sub>					
		Mineral <sub>A</sub>	Mineral <sub>B</sub>	Mineral <sub>C</sub>	Mineral <sub>D</sub>					
		Land <sub>A</sub>	Land <sub>B</sub>	Land <sub>C</sub>	Land <sub>D</sub>					

## 3 Main S & T results/foregrounds

### 3.1 Introduction

The detailed objectives per WP are:

- WP1 (Management):
  - Managing the project in such a way that the specified results are delivered with high quality at the agreed deadlines and within the financial boundaries
  - Managing the overall (scientific) quality of the project;
- WP2 (Inception):
  - Scoping the project in consultation with the NSI consultation group and other stakeholders
  - Refining descriptions of WP3-6 and WP7
  - Continuous reflection on approach and progress
- WP3 (Water accounts):
  - Elaborating, refining and testing accounting principles for water as suggested in SEEA and SEEA 2012 (physical water supply- and use tables; integration of spatial and temporal aspects; providing a data set for WP7);
  - Assessing the feasibility and elaboration of valuation concepts (stock accounts, direct use and indirect use, as well as economic valuation) and accounting for water quality (physical, chemical and thermal pollution), and testing these advanced methods for one country (Netherlands)
- WP4 (Waste and material flow accounts)
  - Harmonization of terminology and classification of waste and waste products with economic/environmental accounts, including MFA accounts;
  - Compilation of standardized waste tables
  - Integration of waste and MFA accounts (including providing a data set for WP7);
- WP5 (Forestry accounts)
  - Testing the suggested London Group reporting standard for reporting in practical data gathering. Analysing how the available data can give harmonised statistics on an international level.
  - Providing guidance to the statistical organisations on how to obtain and treat the underlying data. Providing guidance on how to report and use data which are relevant for developing forest management strategies and steering forest related policies.
- WP6 (Climate change issues)
  - Improving the relation between energy accounts, related UNFCCC emission inventories, and environmental/economic accounting systems, most notably allocation to industry sectors (for instance with regard to transport). This work will providing a data set for use in WP7
  - Land use cover change: analysing how Land use cover change reporting under the Kyoto protocol can be related to standard environmental/economic accounts, particularly allocation to sectors. Where possible doing the allocation and expanding the data set to non Annex 1 countries.

- Emission allowances and –trading accounts: developing and applying methods suggested in the London Group to include emissions trading data and –allowances into EE accounts and testing this approach for Europe.
- Other economic response methods: analysing how environmental taxes and subsidies, the environmental goods and services sector, and adaptation and mitigation costs can be incorporated in EE accounts and doing data inventory tests for a few countries.
- WP7 (Integration into EXIOBASE)
  - to update the current input-output data in EXIOBASE from the year 2000 to the year with the most recent and common data availability. At a minimum, this year will be 2005.
  - to use outputs from WP3-6 in providing improved resolution in the input-output data where appropriate
  - to update environmental extensions of EXIOBASE to new base year
  - to integrate outputs from WP3-6 into the EXIOBASE framework making the data ready for further analysis in the case studies
- WP8 (Case studies): design and implementation of examples that test and illustrate the methodology proposals on environmental accounting models made in WP3 to WP6, in the field of water, materials, and climate
- WP9 (External integration): engaging with stakeholders, such as international NSIs, Eurostat, London group, Environmental Protection Agencies engaged in economic and environmental accounting, and researchers on this issue and disseminating the results of the project externally

As indicated, many of the results of WP3-6 were supposed to provide input in WP7, the integration of data in EXIOBASE. Table 3.1 below which subtasks give results that feed into the revision of EXIOBASE planned in WP7. We now will proceed to discuss the main results of each WP.

## 3.2 WP1: Management

The consortium management tasks and achievements were the preparation of the consortium meetings and presentations of the project. Furthermore the termination of one of the project partners and the addition of one new project partner was prepared and managed.

The project collaborated with many other FP7 projects, most notably DESIRE and POLFREE, FP7 projects awarded after CREEA. CREEA also took into account achievement of other FP7 and international projects, such as WIOD and the Australian EORA project. We engaged staff of these projects or used data from these projects. We further collaborated intensively with many players in the statistical world, such as NSIs, Eurostat, and UNCEEA. Our intensive dissemination efforts are described in section 3.10 on WP9: External integration.

Table 3.1: WP's (numbered) and Tasks per WP (preceded by a...f). Underlined: Tasks providing a result feeding into the updated version of EXIOBASE

<ol style="list-style-type: none"> <li>1. Management</li> <li>2. Inception</li> <li>3. Water accounts             <ol style="list-style-type: none"> <li>a. Refine and test SEEAW and relevant water accounting parts of SEEA2012</li> <li>b. Valuation</li> <li>c. Water quality accounts for physical, chemical and thermal pollution</li> <li>d. <u>Data collection and integration into EXIOBASE</u></li> </ol> </li> <li>4. Waste and MFA Accounts             <ol style="list-style-type: none"> <li>a. <u>Harmonization of terminology and classification of waste and waste products</u></li> <li>b. <u>Integration of waste and MFA accounts</u></li> <li>c. Compilation of standardized waste tables</li> </ol> </li> <li>5. Forestry accounts             <ol style="list-style-type: none"> <li>a. Revising the proposed SEEA 2012 methodology for forests</li> <li>b. Procedures for integrated forest data into SEEA 2012</li> <li>c. Testing methodology for selected countries</li> </ol> </li> <li>6. Climate change issues             <ol style="list-style-type: none"> <li>a. <u>Energy and related Air emission accounts: Update of EXIOBASE</u></li> <li>b. <u>Land use cover change accounts</u></li> <li>c. Emission allowances and trading accounts</li> <li>d. Inclusion of other economic responses in SEEA</li> </ol> </li> <li>7. Integrating into EXIOBASE             <ol style="list-style-type: none"> <li>a. <u>Update Supply Use Tables in EXIOBASE</u></li> <li>b. <u>Update Trade linking of SUTs</u></li> <li>c. <u>Update Environmental extensions</u></li> <li>d. <u>Integrate work of WP3-6 into EXIOBASE extensions</u></li> </ol> </li> </ol>
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### 3.3 WP2: Inception

In WP2 all WP leaders, together with the steering committee of the project participated to refine the scope and approach for WP3-7. For WP8 on case studies it makes only sense to refine the approach after all methodological work in WP3-7 has been done. WP9 on external integration is methodologically less relevant. Deliverable D2.1 came available in its final version (report and annex report) in September 2011

Scoping WP7 required the most attention in the inception phase. Both EXIOPOL as FORWAST were complicated projects and much has been learned about the best way of harmonizing SUT and IOT and about which auxiliary data to be used. CREEA had the additional complexity that the Material and waste work in WP4 and the work on fossil fuel emissions and energy flows in WP6 have considerable overlap and interdependency. Chapter 7 of the inception report (deliverable D2.1) describes hence in detail how a workflow was designed that avoids circularities and overlaps, while realizing a high chance that more can be delivered as originally foreseen in the DoW: the creation of a global, Monetary/Physical/Energy EE SUT. Such a SUT not only portrays monetary relations, but also express all product flows in the SUT in mass and energy content.

## 3.4 WP3: Water accounts

### 3.4.1 Task 3.1 Refine and test SEEAW and relevant water accounting parts of SEEA2012

#### *Review and methodological improvement*

Definitions of green water, water consumption and losses were reviewed by all partners. We concluded that there exist differences in definitions between statistics and academia: losses (e.g. leakages) are excluded in academic definitions of water consumption as losses are considered to return to environment; return flows to other river basins are part of consumption. We decided that for data collection purposes we will use the academic definition as this is what is for instance used in the Aquastat database which will be an important source for Task 4. We need to state clearly the definitions behind the data (i.e. provide good metadata).

Works in this subtask have been closely aligned with the current work on water accounts going on at Eurostat. Hence, in the methodological work on water accounts in CREEA we use a water accounting scheme which comprehensively covers all relevant issues – such as blue vs. green water flows, water use vs. water consumption; industrial vs. domestic water appropriation. Furthermore the scheme includes additional relevant sectors (e.g. agriculture, energy). In a next step we checked for data availability to fill the accounts, especially with regard to availability of real vs. modelled data. The outcomes of such accounting schemes are indicators that can then be used as environmental extensions for the EXIOBASE. Hence, we also did the exercise from the other end by screen for relevant indicators useful to be used as extensions – in order to set relevant boundary conditions for the design of the accounting scheme. The scheme focuses on the following indicators:

- Water use (per GVA, per product output)
- Water consumption (per GVA, per product output)
- Ratio: "water consumption"/ "water use"
- Ratio: Losses in distribution / "total water use"

#### *Integration of spatial and temporal aspects*

TU TWENTE provided data on agricultural water consumption (green and blue water footprint) that is spatially disaggregated to ETH for inclusion in the EXIOBASE. ETH developed different schemes on how to link spatially resolved data on product level to spatial units and sectors of the MRIO model. Agreement on how to properly manage the data transfer from high resolution models in order to ensure consistent updating of the MRIO data in future (within the group and with members from other relevant work packages). ETH also further developed water consumption data to be used for uncertainty consideration comparing with data from TU TWENTE.

#### *Compiling and testing the full set of water accounts for the Netherlands*

CBS reviewed draft PSUT tables proposed by the Eurostat Task Force on Water Accounts twice. As these tables are still being revised, actual filling of these tables has been delayed towards early 2013 when a more definitive version should become available. In the end, CBS compiled experimental PSUTs for the Netherlands for the first time for 2007.

### 3.4.2 Task 3.2 Valuation

CBS worked on the valuation of the provision service of water. Given the difficulties with the resource rent method that was applied for valuing the provision service of water used by the water supply industry, the replacement cost approach was further extended towards desalination and cooling towers. Herewith an experimental valuation of various types of water resources was obtained that is consistent with National accounts principles.

ETH compared traditional methods for water valuation and a method based on monetization of environmental damage indicators. In contrast to traditionally used freshwater valuation techniques, endpoint damage assessment methodologies, which attempt to integrate potentially adverse impacts of freshwater consumption into life cycle impact assessment (LCIA) investigations, in combination with economic damage values have not yet been used for water valuation purposes. In order to examine their applicability for the economic valuation of specific freshwater related goods or services, a global endpoint damage monetization was conducted, and applied methods as well as resulting estimates were compared to the state-of-the-art based on an economic water value compilation for the USA. A final report was written in which the outcomes of both approaches are described.

### 3.4.3 Task 3.3 Water quality accounts for physical, chemical and thermal pollution

TU Twente have modelled diffuse emission of nitrogen and phosphorus from agricultural land. The estimate was done for all crops at high spatial resolution account all nutrient inputs (fertilizer, manure, bio-fixation, nitrogen deposition) and nutrient output (nutrient removal with harvest crop and crop residues, gaseous losses of nutrient nitrogen). Finally, the N and P emission result were aggregated to CREEA regions and product level and integrated into EXIOBASE.

ETH carried out a study whereby life cycle impact assessment methodologies for the environmental assessment of phosphorus emissions were compared with the grey water footprint method. The two methods were tested for phosphorus emissions from sectors in the Netherlands and in Greece. The results were analysed and the relative merits and drawbacks of the two methodologies were discussed.

ETH modelled on a global scale the freshwater thermal emissions originating from thermoelectric power plants with once-through cooling systems. The data for the calculation of the total heat rejected into freshwater bodies from such power plants came from a global power plant database. Since no explicit data on the cooling water discharges were provided in this database, a method based on the appropriate thermodynamic cycle (Rankine cycle) was applied, accounting for the type of technology used in each power plant. The results were aggregated into CREEA countries and regions and integrated into the EXIOBASE.

Overall this led to data sets for nutrient and thermal emission data and a final report describing the two methods for the assessment of nutrient emissions.

### 3.4.4 Task 3.4 Data collection and integration in EXIOBASE

Throughout an inventarisation of available data sources on water use and consumption disaggregated by economic activities (other than agriculture sector) performed by SERI the following steps were carried out:

- Quality check
- Check for potential to fill water accounts
- Check for real vs. modelled data
- Check for "indicator potential"

The inventarisation revealed that few data sources are available that would allow for a detailed breakdown of water use/ consumption by economic activities. As a consequence, for the EXIOBASE 2.0 modelled data was used. Data on water consumption in the agricultural sector was taken from the Water Footprint dataset provided by the University of Twente and from a dataset provided by ETH Zurich. Data on industrial water use and consumption (livestock, manufacturing, electricity production, domestic) was provided by University of Kassel which apply the WaterGAP2 model. All the data were disaggregated into a maximum number of product detail and then allocated to relevant sectors/product in the EXIOBASE (see D3.4).

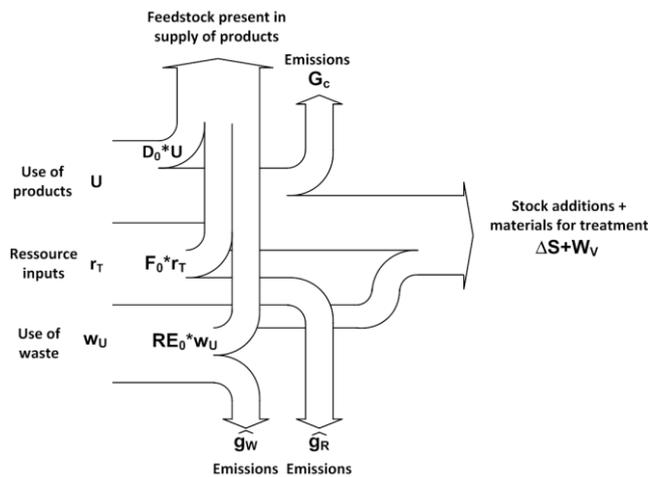
ETH carried out research on disaggregation and compiled the disaggregation matrix.

## 3.5 WP4: Waste and MFA accounts

### 3.5.1 Introduction

We used the following approach for integrating waste accounts in MFA and in the supply-use framework. Waste generation in an industry sector or a household can originate from three different sources; use of products, extraction of resources, and from input of waste (in waste treatment activities). Based on physical supply and use tables, emissions tables, resource tables, and transfer coefficients, it is possible to calculate the amount of generated waste per sector specified on the product, resource or waste from which it originates. The transfer coefficients referred to above specify the proportion of inputs that are carried on into the supply of products or emitted as emissions, see the figure below.

The model for the accounting system presented above is a gross recording of waste flows, where a material can become waste more than once; e.g. first a newspaper becomes paper waste, and in the paper recycling activity, part of the waste paper become waste output (reject from reprocessing of waste paper into new paper).



**Figure 3.1: Approach for integrating waste accounts in MFA and in the supply-use framework**

The calculation inputs to the approach demonstrated in the figure above are: Physical supply and use tables, resources table, emissions table, and tables with transfer coefficients. Since most waste is handled within the economy (traded with positive or negative monetary value), the flows of waste are also integrated into a hybrid version of the supply and use tables, where the waste treatment service products are in physical units (mass of waste derived from the waste table WV). This is done in physical units since the price of the waste material tells little about the quantity and the direction of the flow. In the supply-table, waste treatment and recycling activities supply the service to treat a physical quantity of waste, e.g. the activity 'recycling of waste paper' supplies: 1) the services to treat waste paper (main product of the activity), and 2) recovered paper. Some waste treatment activities supply by-products (recovered materials or energy) and some do not. In the use-table, the use of the service 'to treat waste' is specified. E.g. households that generate 1 kg paper waste may use 0.5 kg 'recycling of waste paper' and 0.5 kg 'Incineration of waste paper'. Information on the national waste systems is necessary to direct the total quantities of each waste type to the designated waste treatments; e.g. recycling, incineration, and landfill.

The WP consisted of three tasks concerning harmonizing terminology and classification, developing the aforementioned methodology for linking waste and MFA accounts further, and collection of data including creating a data set for integration into EXIOBASE and more detailed and precise set of waste accounts in the Netherlands.

### 3.5.2 Task 4.1: Harmonization of terminology and classification of waste and waste products

This task developed a presentation of the system boundaries, definitions and classifications recommended by the System of Environmental-Economic Accounts (SEEA) with regard to material flows and especially solid waste. The SEEA provides an internationally agreed conceptual framework to measure the interactions between the economy and the environment and the state of the environment (United nation et al, 2003). Alignment between the SEEA and the CREEA database will increase the usability of the database, especially by national statistical institutes. Alignment can be achieved by directly implementing classifications recommended by SEEA, such as ISIC (Industries)

and CPC (products). In other cases alignment with the SEEA terminology can be obtained using conversion or bridge tables.

The deliverable of this describes in detail the applied terminology and framework for MFA and waste accounts in the CREEA project. The overall framework for MFA is physical supply-use tables (PSUT) following the same product and activity classification as the monetary supply-use tables (MSUT) in the CREEA project. Product balance is achieved as: supply of products plus imported products which is equal to use of products plus capital formation plus final use plus export of products.

### **3.5.3 Task 4.2: Integration of waste and MFA accounts**

This Task resulted in the Technical report and data set Task 4.2: Physical supply-use tables including the relevant extensions for calculating waste accounts for 43 countries (pilot countries with detailed data collection and modelling: Germany, USA and China) to be integrated in the EXIOBASE.

This report describes the mass-flows data collected and how they have been used in order to have fully balanced physical supply and use tables (PSUTs) that are fully consistent with the monetary accounts.

The amount of collected data is large. Data collection had to meet two requirements;

- the search for reliable data with enough detail to satisfy the requirements of the CREEA data set, and
- the choice of data sets that are continuously upgraded, since reproducibility of the database production needs to be ensured.

Thus, working with such guidelines in mind, the data collection was firstly driven towards international agencies databases, such as FAO, IEA, Eurostat and so on, and only when these were not exhaustive, alternative sources were used, i.e. specialized websites or scientific journal papers.

The explanation of the data collection process in the current report has been divided in chapters according to different accounts of PSUTs.

It was decided to delay the finalization of the deliverable to make room for a more automated PSUT generation procedure. In the DoW it was foreseen to collect detailed data and to carry out highly refined mass balanced PSUTs for only three countries: Germany, USA and China. The automated data processing procedure allowed having the same level of detail of data inputs and refined mass balances for all 43 countries and four rest of world regions. The automated PSUT generation procedure will be used for the creation of time-series of PSUTs in the ongoing FP7 DESIRE project.

### **3.5.4 Task 4.3: Calculating standardized waste tables for the Netherlands**

This Task concerned the compilation of detailed, CREEA based waste accounts for the Netherlands. A comparison was also made with the Dutch waste accounts that are regularly compiled as part of the Dutch environmental accounting program.

The report includes a comparative description of the waste account as of the Dutch environmental accounting program as well as of the CREEA approach. The major differences in the set-up of data in the two approaches are summarized in the table below:

<b>CREEA approach</b>	<b>Data Statistics Netherlands/SEEA</b>
No distinction products and residuals	Distinction between products and residuals
Principal output of waste treatment activities is a service. Mass output is a coproduction. Sectors who produce waste always make use of waste services.	Waste is always assigned to sector where it is produced for the first time
Waste of waste is included because of modeling aims of CREEA	Waste of waste is not included in the Dutch data
Unused flows are included in the model	Unused flows are excluded in the model
Import and export are included	Import and export are included
Use is equal to supply less residuals. Residual waste is a balancing item.	Use is equal to supply. There are no stocks.
Data are in dry matter	Data are in wet matter
Detailed waste categories not fully corresponding with SEEA classification	SEEA waste categories
Discarded materials are not a separate category. Not all categories of SEEA and Statistics Netherlands are covered.	Discarded materials are a separate category. There are more waste categories than 2.0 LCA has taken into account.

Effort has been put in order to remove differences in the frameworks and synchronize the approaches in order to compare the total supply and use. However, even after such a harmonizing procedure, discrepancies of a reduced magnitude still exist. Possible explanations of differences between the CREEA results and CBS data are the following:

- Total use of waste comes from different statistical sources (see Task 4.2 above). Therefore divergences are a consequence of the different assumptions adopted by the sources more than a difference between CREEA and CBS approaches.
- In the CREEA model, waste supply consists of supply of the current year plus the increase of materials accumulation. In the Dutch waste accounts only supply of the current year is taken into account.
- Another reason can be that CBS does not estimate the waste of waste while CREEA does. Waste of waste is necessary for modelling purposes and this causes a double accounting of some waste flows when totals are calculated. These differences in aims surely determine a divergence of results of some extent.
- A third reason is that the percentages of dry matter as used in this analysis results in some discrepancies.
- Another final reason could be the different methods applied. CREEA determines the waste accounts based on the mass balance of the Dutch economy. From one side, this approach can estimate the unregistered waste that could not be taken into account by official surveys because discharged illegally. On the other side, the CREEA approach may be biased whenever the source data are incorrect.

Concluding, the differences in outcomes of the CREEA approach to generate waste accounts and the Dutch (CBS) approach are to a large extent caused by differences in concepts and methods. Most notably, the inclusion of waste accumulation, the placement of recycling activities within ISIC, dry versus wet matter, the distinction between product and residual and including or excluding waste of waste. The main conclusion of this research for WP 4.3 of CREEA is that at this moment the current dataset of the CREEA model is not completely useful for filling in the SEEA tables – because of different waste supply definitions and purposes of the frameworks. However, it should be relatively simple to either adjust the one or the other definition in the future, although some discrepancies could still exist due to the different aims. However, further efforts need to be done to make the two approaches more compatible as well as improving the data inputs for the CREEA data sets which are the precursors of all calculated wastes due to the mass balance approach.

## 3.6 WP5: Forest accounts

### 3.6.1 Task 5.1 Revising the proposed SEEA 2012 methodology for forests

The first task in WP5 was aimed at revising the proposed System of Environmental and Economic Accounting 2012 (SEEA 2012) methodology for forest accounting. As a result the first deliverable, D5.1 was produced and delivered in due time. The revision was focused on four main aspects described below together with the main findings related to them:

- Review the proposed changes in SEEA 2012 with regards to the previous version of the tables (SEEA 2003) and analyse their usefulness of these changes: A comparative revision of SEEA 2012 and SEEA 2003 was accomplished. It was hindered by the updates of SEEA 2012 that obliged us to go through the SEEA 2012 several times very thoroughly to track the changes across the different versions
- Evaluate the completeness of SEEA 2012 forestry tables and propose options for improvements: Although some promising steps on the classification were undertaken, the in- depth assessment of SEEA 2012 revealed that forest accounts lack a number of key aspects related to forests as its focus is merely on forest land and timber.
- Estimate the feasibility of implementation of the SEEA 2012, and estimate the usefulness of the SEEA 2012 for the development of forest policies or strategies: These two objectives of task 5.1 are to be based on the findings obtained from the abovementioned reports and theoretical frameworks analysed but foremost will be based on the responses to the questionnaire the experts gave to the questionnaire delivered to statistical offices. Foremost it is the lack of data that hinders the broaden of the forest accounts. It would imply a budgetary effort from the countries that may not be justified due to the low attention forest issues gather.

### **3.6.2 Task 5.2: Developing procedures for integrating national forest data into the proposed SEEA 2012 framework**

This task concentrated on two main subtasks.

1. Exploring whether and how national data would have to be adapted to make it consistent with the proposed standards in SEEA forestry accounts.
2. Proposing procedures that could be applied at the level of member states or international level to make the existing data consistent with SEEA 2012 requirements.

In the case of the proposed SEEA forest land classification, countries are reluctant to adopt it as they already adopted to the FAWS classification as established by EUROSTAT. This approach is in contrast with the one proposed in SEEA that deliberately aims at accounting for forest land not focusing only on its timber resources, and shows that different focus is considered in the EU.

Some of the improvement proposals for SEEA, such as establishing an account on forest hazards or a management account were regarded as interesting. However, these accounts would have to face additional difficulties related to the risk of double counting as many forest management activities or land use are multi-purpose and hence, establishing their main aim could be troublesome.

### **3.6.3 Task 5.3: Testing the methodology by data gathering for selected countries**

The aim of Task 5.3 was testing the SEEA 2012 framework and the proposed improvements on two case study regions/countries. For accomplishing this aim two case studies were selected: Catalonia (Spain) and Sweden. The selection of the case studies was related to the location of the project partners (EFI, SCB) active in WP5

According our experience the SEEA central framework definitions are made from a national accounts view, planned to facilitate the comparison between sectors and countries. Furthermore, it seems suited to monitor cases where the forest land is undergoing significant changes (i.e. land use changes towards agricultural and urban land where timber resources are being depleted). However, when dealing with forest areas where timber is not the main forest product (e.g., Mediterranean countries) not accounting for non-wood forest products or relevant ecosystem services produces an undervaluation of these forests, which is exactly one of the aspects that environmental accounts try to overcome. Hence, for such countries/regions the implementation of forest accounts might be not so appealing with the suggested system boundaries. The environmental economic questions regarding forests would need a classification that went more in depth about management of forests in order to answer to more environmental issues concerning forest management. As it stands now the system boundary is between economically managed forests and "natural" forests. This is too crude for the purposes that we see.

We found also some data problems when applying the SEEA framework. Although the framework appears rather simple, the data collection process was time consuming and required a number of significant assumptions. This has significantly hindered the whole process and also the possibility of advancing in data analysis.

## 3.7 WP6: Climate change issues

### 3.7.1 Task 6.1 Energy and related Air emission accounts: Update of EXIOBASE

The main objective of Task 6.1 was to deliver updated energy and air emission accounts for EXIOBASE, which has been completed. Complete physical energy supply and use tables, as well as the extensions for gross energy supply and use, combustion related energy use and air emissions have been delivered for each year (43 countries and 5 rest of the world regions).

Energy accounts use the IEA energy balances as starting point and are then transformed from the territory to the residence principle to comply with the SEEA accounting principles. The main activities affected by the switch from the territory to the residence principle are international transport activities, which required the production of transport models for international navigation, international aviation, road transport and fishing. After producing consolidated energy supply and use tables in IEA format that are compatible with the SEEA accounting rules, the energy uses related to the IEA energy flows and energy products have to be allocated to the specific economic activities and products represented in the EXIOBASE database.

Air emissions have been calculated by applying the TNO Emission Assessment Model (TEAM) which calculates emissions according to the structure and methodologies used by the IPCC Guidelines for National Greenhouse Gas Inventories, and the EMEP/EEA Guidebook for air pollutant inventories. These guidelines include the best available emission factors from literature sources, and give guidance on the activity data which these need to be combined with. These methodologies have been applied at a global scale, taking into account technology specific information when available. For other sources however, one generic emission factor is used for all countries, since the collection of country specific information on technologies is not feasible, and the sources is not a major contributor to the total emissions.

In terms of substances, the database includes key greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O), key air pollutants (NO<sub>x</sub>, SO<sub>x</sub>, CO, NMVOC, NH<sub>3</sub>), particulate matter, heavy metals and persistent organic pollutants. Emissions of SF<sub>6</sub> as well as PFC and HFC emissions have been added from other emission datasets, since not all data needed for estimating emission factors were available.

The resulting dataset provides a state-of-the-art energy and emission accounts for all the CREEA industries and products, for the year 2007, for 43 major countries in the world + the rest of the world. Additionally, the results have been expressed as energy use and air emission factors to ease their use in WP4 when generating the hybrid supply and use tables.

### 3.7.2 Task 6.2 Land use cover change accounts

The main objective of Task 6.2 was to deliver land use change accounts for EXIOBASE, which has been completed. Completed as well were deliveries of land use data as environmental extensions to EXIOBASE.

Land use and total (or gross) land use change data were analysed with focus on UNFCCC national inventory data and CORINE land cover data, and in comparison with FAO data and specific national data. For the European countries for which CORINE data are available, this database represents in most cases the preferable one with regard to land use change. The data quality and comprehensiveness however differs a lot between the individual countries. Due to restricted or unclear data availability other global or international databases could not be used to derive data for gross land use change. Data from FAO and in particular the Global Forest Resources Assessment could be used to indirectly estimate net land use changes such as cropland expansion as a result of deforestation. This was not further elaborated here but specific studies on the issue exist.

Alignment of land use / land cover accounts with SEEA 2012 is currently hampered due to different classification systems. Further, available data do not fit with proposed SEEA categories which are in turn characterised as being provisional. With regard to land use change, our proposal is to keep it in a separate account by country/region which might be aggregated to a global account once comprehensive, harmonised data sets become available. The effects on land use change could then be included by linking the land occupation (as above) to the global market for land (the global LUC matrix).

A summary of the status of land use change data for 2007 in CREEA is given in Deliverable D.2. As envisaged in the DoW, complete land use/land cover change accounts – by categories given in the national inventory reports - could be obtained for most Annex I countries in CREEA (twenty-nine in total out of 35) – even though using CORINE land cover data for most of them. For six Annex I countries listed in CREEA, LUC data were incomplete, i.e. Australia, Canada, United Kingdom, Greece, Japan, USA. For the Non-Annex I CREEA countries Brazil, China, Indonesia, India South Korea, Mexico, Taiwan and South Africa there were no data available.

The resulting dataset provides a state-of-the-art land use change accounts (in km<sup>2</sup>) by categories forestland, cropland, grassland, wetland, settlements, and other land, for 43 major countries in the world plus five rest of the world regions in 2007. Further, two datasets for land use (in km<sup>2</sup>) were delivered to EXIOBASE by CREEA land use categories, for 43 major countries in the world plus five rest of the world regions in 2007.

### 3.7.3 Task 6.3 Emission allowances and trading accounts

The main task of this deliverable was to look into the availability of data on emissions trading mechanisms and analyse to what extent these data are sufficiently available to enable linking to emissions and economic accounts. The three mechanisms under the UNFCCC Kyoto Protocol were studied in this context: emissions trading, the Clean Development Mechanism and the Joint Implementation. The study has looked into the kind of information which is available about the flexible mechanisms of the Kyoto Protocol

and investigates whether the available data can be used in filling the Standard Tables developed in the work a SEEA. Moreover, it identifies and describes two case studies from the EU ETS: Denmark and the Netherlands.

It is concluded that currently available datasets are insufficient to develop a methodology that will allow to quantitatively express economic intensities related to the flexible mechanisms of emission trading, joint implementation and clean development mechanism. For many datasets, the level of detail is insufficient. In cases when more detailed data are available, confidentiality is a major obstacle for the data to be used in SEEA.

### **3.7.4 Task 6.4 Inclusion of other economic responses in SEEA**

The main task of this deliverable was to identify and study the most climate related environmental taxes and subsidies as such, and to analyse ways to link them to the emissions accounts. National studies were taken as a basis and the data situation on a general EU level was assessed. The available EU data is not available in a format by industry that allows the data to be included in an accounting framework. For this, a new a general EU method needs to be developed in order to get to a harmonised EU account, especially concerning the subsidies.

The work was focussed on those parts of the taxes, subsidies and EGSS that have a direct relation to the climate issue. These parts have not been identified as a subset before. The report highlights ways to deepen the analyses and the linkages to the emissions accounts. On the adaptation and mitigation expenditure side, the data situation was not sufficient to make analyses. More work on the testing the classification is needed by countries before the area can be included in analysis work.

## **3.8 WP7: Integration into EXIOBASE**

### **3.8.1 Task 7.1 Update Supply and Use Tables (SUT) in EXIOBASE**

The task was mainly focused on collection and reconciliation of data and creation of disaggregated set of Supply and Use tables. Whilst in the DoW work was planned to focus purely on monetary accounts, the availability of data and insights from WP4 mean that planned work shifted to an integrated approach between the monetary and physical accounts. By Month 25 the first full SUT accounts were available, and along with integration of later tasks, a full EE MR SUT was available in Month 27. Two more revisions were made to the SUT after month 27, because (as to be expected with such large datasets, and integration of so many different partners), some outlier values were found that were in need of correction. A mid-term revision was undertaken in Month 32 on priority changes, before a final update was made in Month 36 at the conclusion of the project. Because of the efforts to automate all procedures in the SUT work, these updates went smoothly with low time-cost for WP7 (especially considering work had officially concluded on the work package). It was found to be very useful to have the case studies running alongside these revisions in the project, and having the same institutes involved in the case studies as the WP7 work, as a much more fertile use of time spent error checking and correction was possible.

A number of consistency checks are already included into the automatic disaggregation procedure, and the draft disaggregated tables satisfy these conditions. The checks include product- and industry-wise balance between the Supply and Use Tables, identity between the original SUTs and reversely aggregated SUTs in the EXIOBASE 2.0 classification. Further checks such as homogeneity of supply table, coefficient size, environmental intensity size were applied to the final SUTs. An internal review has been made on the outputs of the procedure for the basic price/import/margin layer estimation from the purchaser price table. As a result of this review, refinements to the margin and tax layer have been implemented.

### **3.8.2 Task 7.2 Update Trade linking of SUTs**

A trade linking procedure was already available as part of the EXIOBASE software from the EXIOPOL project. In CREEA, further work was done on the trade data to have a more consistent representation of data going into the trade linking. A new module was developed that uses data on trade and transport margins, ensures global balance between the margins and output of margin producing sectors, adjusts for higher quality data on energy flows from the IEA (necessary for physical/monetary links) and keeps intact the production and consumption structure of the disaggregated SUTs from Task 7.1. The result was that a much smoother implementation of the trade linking procedure was performed in the EXIOBASE software without high need for outlier adjustments. Results from work on this task includes:

- Trade data was collected from the reconciled BACI trade database, which is produced by CEPII institute. The BACI database is based on Comtrade dataset<sup>1</sup>.
- Services trade data from UN services trade was collected, cleaned, and implemented.
- Concordances between trade data and EXIOBASE Classification were updated. The UN service trade database provides the data in multilayer classification, the availability of data on the lower level of classification varies from country to country. The concordances are created between the EXIOBASE 2.0 classification and all the levels of the UN service trade database classification.
- The trade linking routine was revised to estimate international trade and transport margins and go between consuming country basic price and producing country basic price.

### **3.8.3 Task 7.3 Update environmental extensions**

Original data on environmental extensions within EXIOBASE are generally available for updated base years. However, new data on water, GHG emissions, and waste generation were collected/calculated in WP3 (water), WP4(waste), and WP6(Kyoto). Whilst most of this work occurred in months 1-18, the data collection was finalised in this period. Due to the reconciliation of data between the physical and monetary layers, a number of problematic areas were identified that needed further correction. This work was done before the release of the first SUT data set, but also in the two subsequent revisions (see Task 7.1).

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<sup>1</sup> For more detailed description please refer to: Gaulier et Zignago (2010) "BACI: International Trade Database at the Product-level The 1994-2007 Version", CEPII Working Paper 2010-23.

### 3.8.4 Task 7.4 Integrate work of WP3-6 into EXIOBASE extensions

The integration of the WP3-6 work into EXIOBASE was mainly undertaken in months 21-27, with land material, water, energy and greenhouse gas accounts all being finalised in that period. Most integration work went smoothly, with a few minor modifications needed (see below). The following work was done:

- Import supply-use data, trade data and extensions for the new base year into EXIOBASE.
- Rerun EXIOBASE routines to create the 48 regions trade linked world model to provide the IOT analysis framework in 2000 and the new base year 2007.
- Export the data for further analysis in the case studies in WP8
- Create an additional processing step needed for most EXIOBASE extensions because of the detail of the EXIOBASE model, and the nature material extraction and water extraction data which is estimated on a product basis rather than an industry basis. The use of a Supply-Use system in the System of National Accounts (SNA), as well as the strict definition of an industry in the SNA means that the SUTs reflect the notion that a single industry can produce multiple products (co-production) As co-production is common in many economic sectors, all environmental extensions had to follow the same method of classification. The monetary supply table was used to estimate the quantity of each physical product being produced by each industry.

Whilst the bulk of WP7 work was thus completed by June 2013, some additional time was required for further review and revision of the dataset in the Months 28-36. This was expected – previous MRIO models have always required adjustments because of outlier data due to the sheer volume of data going into the models. Whilst as much effort as possible was used on preventing these inconsistencies, some budget of WP7 was required in the latter stage of the project. Generally, whilst not planned, we feel that this approach worked well, with usable datasets available to the cases in Month 27. Inconsistencies then identified in the cases were then incorporated in later updates

Whilst significant improvements were made in the output of the material, water, forestry and greenhouse accounts, it was clear that some improvements could still be undertaken in order to further operationalize the SEEA alongside the models consistent with the SNA framework. In particular, the difficulty of getting harmonized datasets with broad geographical coverage for the forestry accounts prevented significant advancements to be made in this WP. Furthermore, emissions associated with land use, land use change and forestry were planned to be included in the EXIOBASE model, but no advancement was obtained in this area. This particularly relates to the allocation of drivers of the land-based impacts to individual production sectors, especially in a temporal perspective. We see further need of research on creating consistent methods for this to be done, under the knowledge that no single method would give a completely “true” result.

## 3.9 WP8: Case studies

### 3.9.1 Task 8.1 Case study 1: Sustainable consumption: the water perspective

This case study calculated direct and indirect (embodied) water for (1) international trade and (2) final consumption. With the detailed water accounts developed in WP3 and fed into the EXIOBASE 2.0 in this case study for the first time 'virtual' water flows on a very high level of spatial accuracy and disaggregation were calculated. In additional steps these data were combined with data on nutrient emissions, thermal emissions as well as characterization factors to account for environmental impacts. These results can be used in future monitoring of EU water use and to develop new water management policies, on the regional as well as the international level. The case study was done in the following steps.

- Step 1: Calculation of water footprint type indicators with EXIOBASE (WU / ETH/UTwente). In the first step the EXIOBASE was used to calculate the total water embodied in the final consumption of a large number of products. The resulting data were disaggregated by water type (blue vs. green) as well as by the around 200 different CREEA product categories. The results were used to identify hot spots of direct and indirect water use, analyse the contribution of various consumption areas to the total water footprint and assess cross-country patterns in terms of water use and international trade of embodied water. For the EU-27 as a whole as well as for selected countries an overview of (1) the sources of embodied water consumed (CREEA countries), (2) the water quantities embodied in the specific CREEA products consumed and (3) the sources of water for the main product categories was set up. Furthermore, the spatial disaggregation matrix developed in WP3 was applied to the results to retrieve more specific information on the geographic origins of agricultural water consumption. The calculations were carried out using the Water Footprint dataset from University Twente as well as the dataset from ETH Zürich both being part of the EXIOBASE.
- Step 2: Data and methodological comparison (ETH Zürich / UTwente / WU). The results of the above calculations were compared (1) to evaluate differences in the two datasets in use and (2) with other methods to analyse water use and consumption, such as the Water Footprint methodology (UTwente) and life-cycle assessment methodologies (ETH Zürich) which focus on evaluating the environmental impacts of water appropriation. Such a comparison sheds light on the strengths and weaknesses of the different methodologies, and helps identify where methodological improvements are necessary.
- Step 3: Analysis of thermal and nutrient emissions (ETH Zürich / UTwente/WU). In Task 1 and 3 of WP3 an accounting scheme for thermal emissions from the electricity industry (cooling water from power plants using once-through cooling systems) was developed. This information was fed into the case study and it was used to improve the results computed with the help of the EXIOBASE. Nutrient emission to freshwater system was estimated in WP3 and integrated into EXIOBASE. This information was used to estimate the grey WF related to the emission of nitrogen and phosphorus following the WFN approach.
- Step 4: Developing an integrated approach and final case study report (WU with inputs from UTwente and ETH Zürich). In step 4, the final report of this case study was written. The different sections of the final report followed a harmonised

structure of a scientific paper, in order to allow producing publications from the case study results without huge efforts. The partner responsible for the work in each step was also responsible for the compilation of the respective report text.

### **3.9.2 Task 8.2 Case study 2: Embodied material flows and headline indicators on resource use and resource productivity**

The second CREEA case study contributed to the development of robust and comprehensive indicators (i.e. RMC and TMC) of European material use and material productivity through assessing the global material resource use related to final demand of the EU. It thus responds to the policy needs in particular in the context of the Resource Efficiency Roadmap. The case study team applied the EXIOBASE system as refined in CREEA (EXIOBASE 2.0) using the material flow data prepared in WP4, in order to calculate global material extraction required to satisfy final demand in the different EU Member States. As the base year of CREEA is 2007, calculations were performed for that specific year. The results generated with the MRIO system were then compared both with the results from other groups:

- Applying coefficient approaches: a bottom-up (LCA-oriented) coefficient approach was applied as an alternative to the MRIO-based calculations. Following this approach, direct imports (and exports) in physical units were multiplied with factors representing the (used and unused) indirect material requirements. For the first time, the Eurostat RME coefficients were applied for the calculation of RMC of all EU-27 Member States in this CREEA case study.
- Applying MRIO based approaches
  - GTAP (Global Trade Analysis Project) MRIO approach
  - WIOD (World Input-Output Database) MRIO approach
  - EORA MRIO approach
  - OECD MRIO approach

The comparative analysis revealed the advantages of the different methodological options and allowed deriving suggestions on how different options might be integrated in a "hybrid" approach, applying MRIO-based calculations for some products and product groups, and coefficient-based calculations for others depending on the specific advantages of each approach.

### **3.9.3 Task 8.3 Case study 3: Policy applications of GHG, land and forestry data extensions**

Case study 3 focussed on showcasing the outcomes of the work on linking environmental and economic accounting, in particular for greenhouse gases, and, to a lesser extent, associated impacts on land use and employment. As per the Description of Work, three sub-tasks were planned as follows:

1. Review of policy needs and scenarios;
2. Update and expanded analysis of consumption based carbon accounts;
3. Analysis of drivers of change in consumption-based carbon accounts via decomposition analysis.

All three sub-tasks were completed in this work period. An initial effort was undertaken on the review (first sub-task) at the start of the case study period, with some minor revisions undertaken throughout the remainder of the period. Focus was placed on the utility of the use of the SEEA and SNA frameworks in particular for consumption-based accounting, and what were the main research gaps in terms of policy requirements. A secondary foci was placed on a methodological review of the science behind the decomposition analysis.

Based on the general review, the second sub-task focussed on firstly updating the carbon footprint analysis for the CREEA datasets, focussing on headline results, major supply chains, and analysing impacts by product category. Relationships between development statistics and environmental impacts were further analysed. This led into a productivity assessment, looking at trade-offs between labour, energy and associated greenhouse gases. A further assessment was undertaken of the robustness of the rest of the world modelling for environmental footprints. Utilising the CREEA outcomes in this case study was very useful in terms of further enhancement of the database, including error detection, refinement of approaches and obtaining confidence in results. A focus on the contributions of greenhouse gas emissions from agricultural production, and associated land use, land use change and forestry was not undertaken as hoped for in the description, because no major advancement on the accounting side had been made for these particular issues in earlier work-packages, which would thus have not allowed any addition to the literature from an analytical point of view.

Finally in the third sub-task, a decomposition analysis was performed over the two iterations of the EXIOBASE datasets. This allowed for the investigation of the impacts on results of methodological choices, and for the investigation of detailed changes in the supply-chains of the global economy over the two base years of EXIOBASE.

#### **3.9.4 Booklet: the global resource footprint of nations**

The CREEA booklet 'The Global Resource Footprint of Nations. Carbon, water, land and materials embodied in trade and final consumption calculated with EXIOBASE' is a main additional result of the CREEA project. The booklet provides a comprehensive insight into the global environmental footprints of final consumption. Using EXIOBASE, it presents 43 country factsheets encapsulating the carbon, water, land and material footprint of final consumption in the countries covered by EXIOBASE, i.e. the EU-28 plus the 15 main EU trading partners. The booklet further showcases the interconnectedness of the global economic system and the links between production and consumption as well as its relation to global environmental impacts. It illustrates that a large share of the carbon, water, land and material footprint of many developed countries is located abroad. Also, a number of comparative analyses, such as how environmental pressures correlate to GDP or the Human Development Index (HDI) of a country are provided. By that means, the booklet provides indications where hot spots of necessary (political) action can be identified.

### **3.10 WP9: External integration**

This WP is not further described here, but in chapter 4 since it mainly concerns dissemination.

## 4 Potential impact and the main dissemination activities and the exploitation of results

### 4.1 Introduction

Furthermore, the added value of carrying out this work at EU level rather than member state level must be discussed. We will discuss these issues below, starting with European added value, followed by the 4 topics above (where we will include the expected impacts with regard to waste accounting under MFA/Waste), ending with an overall assessment of contributions to SEEA 2012. More generally, we would like to stress that in each content area covered we discussed thoroughly with the NSI members in our team what main topics could be addressed given discussions in the London Group, and what would be priority issues to be addressed given the potential of a project like this.

### 4.2 Impact

#### 4.2.1 Introduction

The expected impact listed in the Work Program is formulated as follows:

*Contribution to the development of the system of Integrated Environmental and Economic Accounting 2012 (SEEA 2012). In relation to the waste component, the project is expected to improve the comparison of waste stocks and the monitoring of international waste flows through the harmonisation of the classification used for the Waste Statistics Regulation with other classifications for waste generation and treatment operations.*

The call text itself focuses on the following issues:

1. Regarding water, the main issues to be dealt with are water classification and valuation and water quality accounts.
2. In terms of waste, issues that could be further researched include: harmonization of the terminology and classification of waste and waste products across countries. Standardized waste tables could also be developed, taking into account already existing research. A link between waste accounts and Material Flows Accounts (MFA) could be created.
3. Also, some forest values have been incorporated in environmental accounts, but much of this work has not yet been systematically incorporated in the integrated economic and environmental accounts.
4. Finally, the link between integrated economic and environmental accounts and Kyoto protocol inventories and other climate change policy relevant concepts could also be investigated.

## 4.2.2 Reflection on impact

The experience of this project showed clearly the value of executing this work at EU rather than Member state level. Much of the work implied support of harmonization of statistical standards and testing such standards, most notably SEEA 2012. It simply is not efficient if each NSI is doing this on its own. As will be discussed under dissemination, the results of this project were effectively brought into the formal meeting frameworks of NSIs and discussed there. Indeed, this project is likely to create added value beyond Europe – various partners have close relations to initiatives such as the UN's Green Economy Initiative and the UN Panel on Natural Resources. The result of this project (methods, data and integration into a harmonized database) is highly useful for such global initiatives. As will be discussed under Exploitation, there is a fair possibility the results of the projects may be used at UN level.

We further would claim that the expected achievements and impacts with regard to water-, Waste/MFA, forest- and climate change accounting all have been met (quotes taken from the original Work item description).

### **WP3 Water: "the main issues to be dealt with are water classification and valuation and water quality accounts"**

In WP3, the project has:

- Elaborated, refined and tested accounting principles for water as suggested in SEEA and SEEA 2012 (physical water supply- and use tables; integration of spatial and temporal aspects; providing a data set for WP7);
- Assessed the feasibility and elaborate valuation concepts (stock accounts, direct use and indirect use) and accounting for water quality (physical, chemical and thermal pollution),
- Tested these advanced methods for one country (Netherlands) by Statistics Netherlands

By this, the project will have shown feasibility of dealing with classification, valuation and quality issues. Through its external integration with European NSIS in WP9, its practical showcasing in WP7 and 8, and work of the partners in practical projects for Eurostat, the project will bring the practical application of advanced methods for water accounting a major leap forward, and pave the way for formal application by NSIs.

### **Waste/MFA: "Harmonization of terminology and classification, development of standardized waste tables, and links between waste and MFA accounts", aimed at improved monitoring of international waste flows.**

WP4 was totally devoted to the question of how to relate material flow accounts with waste accounts and stock data. Harmonization of waste classifications was a key issue in the WP. Standardized waste tables will be compiled. By this, the project has shown feasibility of harmonizing waste classifications and integrating waste and MFA accounts, and developed standardized tables and data sets. Through its external integration with European NSIS in WP9, its practical showcasing in WP7 and 8, and work of the partners in practical projects for Eurostat, the project has brought the practical application of advanced methods for water accounting a major leap forward, and paved the way for formal application by NSIs.

**Forests: “much work has not yet been systematically incorporated in integrated environmental and economic accounts”.**

WP5 of this project:

- Tested the suggested London Group reporting standard for reporting in practical data gathering. Analysed how the available data can give harmonised statistics on an international level.
- Provided guidance to the statistical organisations on how to obtain and treat the underlying data, and provided guidance on how to report and use data which are relevant for developing forest management strategies and steering forest related policies.

The troubleshooting during practical application and showcasing of results, paved the way for practical application by NSIs. WP9 paid special attention to engagement of other NSIs in the project.

**Climate change issues: “the link [with] integrated economic and environmental accounts could be investigated”.**

WP6 focused on the following jobs:

- Improving the relation between energy accounts, related UNFCCC emission inventories, and environmental/economic accounting systems, most notably allocation to industry sectors (for instance with regard to transport). This work will provide a data set for use in WP7
- Land use cover change: analysing how Land use cover change reporting under the Kyoto protocol can be related to standard environmental/economic accounts, particularly allocation to sectors. Where possible doing the allocation and expanding the data set to non Annex 1 countries.
- Emission allowances and –trading accounts: developing and applying methods suggested in the London Group to include emissions trading data and – allowances into EE accounts and testing this approach for Europe.
- Other economic response methods: analysing how environmental taxes and subsidies, the environmental goods and services sector, and adaptation and mitigation costs can be incorporated in EE accounts and doing data inventory tests for a few countries.

By this, the project provided direct links between key reporting mechanisms for the UNFCCC (GHG, LULUCF) at a level of (sector) detail that does not exist yet. This will make it easier to compile data sets with environmental extensions/NAMEAs in future.

## 4.3 Dissemination

### 4.3.1 Introduction

The project had an extensive dissemination program, organised in WP9. We here report the main dissemination activities by task.

### 4.3.2 Task 9.1 Feedback from/engagement with NSIs in the London group

An invitation to join a reference group for the project CREEA was sent out in May 2011 to twelve organisations with ample experience in environmental accounting. The group worked mainly via email, but we have also had telephone meetings. They received the reports that came out of the project and was consulted during the running of the project. The progress of the CREEA project has been further discussed and presented to the statistical community on numerous occasions:

- The UNCEEA meeting in New York, 15-17 June 2011, presentation by Arnold Tukker;
- The London Group Meeting in Stockholm, Sweden 12-15 September 2011, presentation by Viveka Palm;
- The London Group Meeting in Ottawa, Canada 2 - 4 October 2012, presentation by Bram Edens and Viveka Palm;
- The London Group Meeting in London, 12-14 November 2013, presentation by Arnold Tukker;
- DIMESA (Director's meeting on Environment Statistics and Accounts), Luxembourg 2013, presentation by Viveka Palm;
- Working group on Environmental Accounts, Luxembourg, 2013, presentation by Sjoerd Schenau;
- Working group on Environmental Accounts, Luxembourg, 2014, presentation by Sjoerd Schenau;

#### **4.3.3 Task 9.2 Support of a Platform on global, harmonized environmental and economic accounting endorsed by a formal institution (e.g. OECD, UNEP, UN)**

Rather than aiming for a process that would provide a dissemination and consultation structure that could only be operational a long time after the project start, opted for a more pragmatic approach. There are already various formal platforms that discuss the environmental and economic accounts and its integration into MR EE IO in the international arena. We hence wanted to make sure all relevant activities in CREEA could be communicated well with such platforms, and that such platforms could give feedback to CREEA. The meetings with the statistical community have already been mentioned under Task 9.1. We additionally organised sessions or meetings during the following events:

- Participation in regular scientific meetings in the field of environmental and economic accounting covered by CREEA (water, materials/waste, forestry, carbon, EE IO). Important platforms include:
  - The World Resources Forum, a major annual conference dedicated to resource efficiency
  - the International Society of Industrial Ecology (ISIE, bi-annual conference; the global top scientific platform for materials/waste and EE IO, organised in specific Working groups),
  - the International Input Output Association (IIOA, annual conference; the most relevant global scientific platform on (multi-regional) input output analysis)
  - the 'Reunion project': a gathering of the 5-6 major initiatives in global Environmentally Extended Input Output Analysis in which CREEA participated, and that could meet 3 times between 2011 and 2013 on the

initiative and with funding from the University of Sydney's International Program Development Fund.

- Participation in ad-hoc conferences and meetings relevant for the CREEA consortium. This included meetings of e.g. UNEP on indicators for the Green Economy Initiative, and OECD on the Green Growth initiative.

Part of the budget available for this task was used to produce popular booklet with the main results of the CREEA project, called The Global Resource Footprint of Nations (de facto a summary of the main case study analyses in WP8).

#### **4.3.4 Task 9.3 Developing an internal and external internet communication platform**

A project website [creea.eu](http://creea.eu) has been developed. The website was used to provide transparency of the different actions in the project and to enable through documentation of activities conducted and activities up-and-coming. It is important for the community of national statistical offices and other agencies producing statistics within the framework of environmental accounts to be up-dated on the proceedings of the project. The website can easily fulfil parts of this need as links will be provided to each topic of the project.

#### **4.3.5 Task 9.4 Disseminating the results of the project externally**

A dissemination event was organised with CBS, SCB and TNO in the lead organisation role. The event was a one day seminar for persons from NSIs, science and policy interested in policy applications of environmental and economic accounting. This final conference was held on March 25 2014 in Brussels for an external audience of researchers, policy makers, NGO members and various other stakeholders, totaling more than 50 people (not counting the CREEA project members). Anna Natasa Asik, European Commission, project officer for CREEA and Arnold Tukker of TNO/NTNU opened the conference (the event is presented in a separate deliverable).

### **4.4 Exploitation of results**

When writing the DoW, as an ideal picture we aimed at setting up a rather formal international platform for this. It is rather clear that to achieve a high level of formalisation, institutional backing from outside the consortium is important. A group of scientific institutes after all never can play a formal institutional role in the environmental and economic accounts arena.

We noted rather quickly after the start of the project that despite our good relations with e.g. Eurostat, other members of the Group of Four, and UNEP and OECD, that having one of these organisations acting as a 'figurehead' for these activities (that would be run via the CREEA resources) would become difficult. International organisations only can host a platform if various individual countries ask for it, which usually happens only after a rather long process of discussion between countries. This led us to a more pragmatic dissemination approach as described in section 4.3.

Significant opportunities for exploitation of results have already been achieved and still lie ahead:

- The testing and refining of SEEA 2012 procedures and data gathering in WP3-WP6 was done in close collaboration with National Statistical Institutes (NSIs) part of the project (Statistics Netherlands and Statistics Sweden). Indeed, these NSIs often already did pilots that tested if the methodologies applied could be used in the context of the rigorous demands set to statistical quality by NSIs. The results were further intensively disseminated with relevant NSI networks, including the London Group and UN CEEA. This implies that certain results already during the project proper have been exploited by user groups.
- One of the main results is a new, detailed integrated MR EE SUT/IOT database, that will be made available publicly by the EXIOBASE consortium (under the protection of a license). This implies that a broad user group can conduct MR EE IO calculations for specific countries, and so on. The availability of EXIOBASE will make such analyses much cheaper as in the past for users, since they will not have to make their own database anymore.
- Many of the routines that have been refined in CREEA to build EXIOBASE 2.0-2.2, will be used again in many other related projects, including FP7 and H2020 projects.
- A very exciting recent development is that the UN Statistical Division now is seriously looking, via UN CEEA, in picking up the experiences developed in CREEA (and a similar project in Australia), to build an MR EE IO that formally can be endorsed by NSIs in the next few years. This process then is to be supported by staff and tools developed in the CREEA project.

## 5 Public website address and contact details

### Website

[www.creea.eu](http://www.creea.eu)

### Co-ordinator Contact details

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