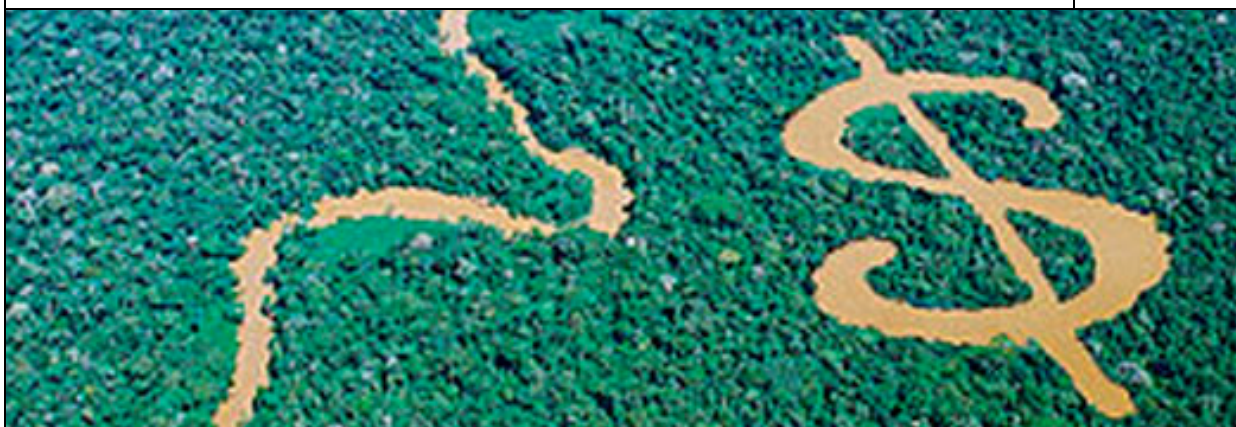




Report Work Package 3 – Task 1:

Refine and test SEEAW and relevant water accounting parts of SEEA2012

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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

Deliverable number:	D3.1
Revision number:	1
Date of current draft:	26 March 2013
Due date of deliverable:	31 March 2013
Actual submission date:	31 March 2013
Dissemination level:	Internal?

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1 Summary

The overall goal of task 3.1 is the comparison and evaluation of existing water accounting (inventory) schemes. For this purpose, an overview of the SEEAW and SEEA frameworks is provided and adjustments for better accounting for water use and consumption are provided. Furthermore, the integration of spatial and temporal aspects is discussed and a structure for integrating is proposed. Two main problems of the accounting are solved: the treatment of losses and of water that is returned to a different river basin. Finally some examples are provided. Furthermore, consistent integration of blue water use and consumption as well as green water consumption is proposed. In the appendix data availability per sector and water use type is indicated.

2 Introduction

In recent years a number of handbooks have been published pertaining to water statistics and accounting. First of all, the *System of Environmental-Economic accounting for water*, commonly referred to as SEEAW (UN, 2012a). Recently, the SEEA Central Framework (SEEA CF; UN et al, 2012) was adopted as an international statistical standard by the UN Statistical Commission. The SEEA CF contains a section which discusses water accounting. In addition, in 2011 the International Recommendations for Water Statistics (IRWS¹; UN 2012b)) were also adopted as a standard by the UN Statistical Commission. Finally, in the academic community two approaches for water footprint have been suggested (UNEP 2012), a handbook on Water Footprint methodology (Hoekstra et al, 2012) and guidance for Water Footprinting from an LCA perspective in line with carbon footprinting (Ridoutt and Pfister 2010, ISO 2013).

The overall goal of task 3.1 is the comparison and evaluation of existing water accounting (inventory) schemes as outlined above and their associated statistical databases (i.e. data on water consumption at Eurostat, AQUASTAT, OECD, UNSTAT, etc.; economic input/output data, modeled data) as well as applied in environmental assessment methodologies (e.g. life cycle assessment). In this context, the project team can build on experience made in the FP-6 project EXIOPOL, the FP-7 project OPEN:EU and especially on the ongoing methodological discussions and developments going on at EUROSTAT where SERI and TU Twente are strongly involved in the related projects. The outcomes of this Task are therefore closely linked to the results in those projects, in order to ensure alignment and mutual support. As a consequence, we decided to use the PSUTs set up by Eurostat and its contractors as a starting point for further methodological discussions. The acceptance and applicability of the SEEAW by all communities involved, namely the hydrological, the water assessment and the statistical communities, is likely to improve as a result of the collaboration in this WP, which consists of representatives of all aforementioned communities.

The SEEAW consists of two parts. **Part I** comprises the categories of accounts for which there is considerable practical experience and for which a consensus on best practices has emerged. It includes internationally agreed concepts, definitions, classifications, accounts and tables, consisting of the following categories of accounts: physical supply and use tables, emission accounts, hybrid supply and use tables and asset accounts. **Part II** encompasses those accounts which are considered of high policy relevance but are still experimental, because international accepted best practices have not yet emerged. They include quality accounts (Chapter 7), valuation of non-market flow of water (Chapter 8) and examples of application of water accounts (Chapter 9). Although part 1 has become a statistical standard as a result of a consensus on best practices, there are still areas of methodological improvement and issues where further research is necessary. For instance, well-known water footprint concepts such as blue, green, and grey water could be better

¹ The IRWS: provides the **main concepts on water statistics**, including definitions and classifications of statistical units related to water and a list of recommended data items that countries are encouraged to compile. It provides general **guidance on the collection and compilation of the water statistics**, in particular on data sources, data quality, data collection strategies and dissemination.

integrated in the accounts. Moreover, the definition of water consumption could be further discussed. Furthermore, conceptual issues such as how hydropower, wastewater, and reservoirs are integrated into the accounts, and definitional issues regarding whether fossil sources are included in opening stocks or not still deserve further elaboration. Some of these methodological issues are taken up in Section 3.

Various formats of PSUTs have been proposed by the SEEAW, the SEEA CF and within the Eurostat project. The PSUT format also allows for integration of water accounts into MRIO tables. An important aspect is whether and how temporal and spatially disaggregated data can be integrated. This issue is discussed in Section 4. Finally, Section 5 contains the results of testing the proposed PSUTs with data available for the Netherlands.

3 Review and methodological improvement

3.1 Definitions of water use and consumption

- i. *The concept of water consumption that is used in SEEAW will be clarified/refined by comparing it with various definitions common in the hydrological community. Top-down statistical accounting schemes (e.g. on sectoral and macro-economic level) will be evaluated against process-based (LCA) water inventories of relevant economic sectors. A methodology will be proposed for how to properly incorporate "hydrological consumption" in water accounts considering that the concept of consumption in national accounts reflects the "overall consumption/use" of economic sectors within administrative rather than hydrological units.*
- ii. *A special focus will be put on adequately describing "net use of water" and losses of water, e.g. due to evaporation and evapotranspiration, and on deriving default schemes to better transform national data to a watershed level.*

We have reviewed the various definitions of water consumption or consumptive use in the statistical and hydrological community. An important element in the discussion is the choice of the system boundary between the economy and the environment in the context of accounting for physical flows. According to the SEEA CF all cultivated biological resources are considered to be within the production boundary (Para 19), and flows of water used by cultivation processes therefore cross the boundary between the economy and the environment and would be considered as used/consumed by the economy. By contrast, water use pertaining to non-cultivated assets (e.g. berries or mushrooms picked in the forest) is considered as a water flow within the environment and would not be recorded as water use/consumption by the economy.

Green water consumption: There appear to be at least four different definitions that are related to where the exact boundary between the economy and the environment is drawn:

- The SEEAW (UN 2012) defines abstraction from soil water as the amount of precipitation that falls onto agricultural fields. The excess of water, e.g. the part that is not used by the crop, is recorded as a return flow to the environment from rainfed agriculture. In principle, in case of cultivation processes, the complete soil is considered to be a part of the economy. Green water can subsequently be defined as the difference between abstraction from soil water and return flows to the environment. For example suppose precipitation is 100 mm/a, return flows (e.g. run-off) are 20mm/a: according to SEEAW water abstraction is 100 mm/a and green water consumption is 80mm/a.
- According to the IRWS (UN, 2012) "*abstraction of water from soil water includes water use in rain-fed or non-irrigated agriculture and forestry. It is the volume of precipitation that falls onto agricultural fields and is then transpired or incorporated into crops, plantations, orchards etc. This is broadly equivalent to the concept of green water.*" This implies a net approach in the sense that water abstraction and green water would be equal. As the focus is on transpiration (and not evaporation) the amount of green water would presumably be less than 80mm/a in the example set out above. However, the distinction between transpiration and evaporation is not generally possible.
- SEEA CF Para 3.196 (UN et al. 2012) states "*Abstraction of soil water refers to the uptake of water by plants that is either embodied in the harvested product or is transpired as the crop grows. It is limited to soil water used in agricultural production and cultivated timber resources. The abstraction of soil water is equal to the amount of transpiration by the crop and is calculated based on the crop area using coefficients of water use, with different coefficients used for different crops and accounting for*

location effects (e.g. soil types, geography and climate)." This seems to be consistent with IRWS, although in contrast to the above two approaches, it seems as if it is no longer the cultivated soil that is considered to lie within the economy, but only the plants.

- Eurostat (forthcoming): *"Abstraction of water from soil water is the water used in rain-fed agriculture and forestry. It is the precipitation on land that does not run off or recharges the groundwater but is stored in the soil or temporarily stays on top of the soil or vegetation. Eventually, this part of precipitation evaporates or transpires through plants. This type of flow is also called "green water". It is the volume of precipitation that falls onto agricultural fields and forests and is then transpired or incorporated into crops, plantations, orchards, etc. Data for this is generally modelled. The up-take of soil water by cultivated plants is closely related to the evapotranspiration by cultivated plants."* This position seems to include both transpiration and evapotranspiration and hence water abstraction and green water would be equal to 80 mm/a in the example set out above.
- In the hydrological community a slightly different approach is taken in the sense that a general concept of consumption exists. While water consumption can be principally divided into green and blue water (Falkenmark and Rockstrom 2006, Pfister and Hellweg 2009), parts of the water footprint community apply the concept also to grey water which is water pollution:
According to the Water Footprint Network methodology (Hoekstra et al 2012): *"The WF is a measure of humans' appropriation of freshwater resources and has three components: blue, green and grey. The blue WF refers to consumption of blue water resources (surface and ground water). 'Water consumption' refers to one of the following four cases:*
 - i. *water evapotranspiration;*
 - ii. *water incorporation into a product;*
 - iii. *water not returning to the same catchment area (for example, it is transported to another catchment area or the sea); or*
 - iv. *water not returning in the same period (for example, it is withdrawn in a dry period and returned in a wet period).*
 - v. *The first component, evaporation, is generally the most significant one. The blue WF is thus often smaller than the water withdrawal, because generally part of a water withdrawal returns to the ground or surface water. The green WF is the volume of green water (rainwater) consumed, which is particularly relevant in crop production. The grey WF is an indicator of the degree of freshwater pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards."*
- According to the water footprint (ISO) methodology (Kounina et al.):
 - *"In nature, precipitation water (liquid or solid) is differentiated in three types of water[flows] that are interconnected: (1) surface water (river, lake, and sea), (2) groundwater (renewable, shallow, and deep) that is only reached through surfacewater and soil moisture, and (3) precipitation water [temporarily stored] as soil moisture (also called "green water") (Falkenmark and Rockstrom 2006). Fossil groundwater compartment is not connected to other freshwater compartments. Freshwater is characterized by less than 1,000 mg/l of dissolved solids (USGS 2012) and encompasses all previously mentioned three types."*

Overall, the Eurostat and SEEA CF definition of green water seems to be aligned with how green water is defined in the academic community.

Blue water consumption

SEEA CF defines water consumption as: *"part of water use which is not distributed to other economic units and does not return to the environment (to water resources, sea and ocean) because during use it has been incorporated into products, consumed by households or livestock [(e.g. evaporated)]. It is calculated as a difference between total use and total supply, thus it may include losses due to evaporation occurring in distribution and apparent losses due to illegal tapping and malfunctioning metering."*

The Water Footprinting community defines water consumption as (Hoekstra et al. 2012, Pfister et al. 2009): *"The volume of freshwater used and then evaporated or incorporated into a product. It also includes water abstracted from surface or groundwater in a catchment and returned to another catchment or the sea."*

3.1.1 Key issues

There appear to be three main issues:

1 The treatment of losses:

The statistical definition considers losses as water consumption, whereas the water footprinting methods do not include losses as consumption assuming that these losses (e.g. water leaked from water mains) return to natural water bodies (surface or ground water). Therefore, it seems that the difference in treatment of losses is related to default assumptions made concerning the type of situation and the time of return.

For example, consider a water supply industry which abstracts 100m³ from river basin A and supplies water via mains to, say, agriculture which receives only 80m³ because 10m³ have evaporated and 10m³ have leaked along the way. Water consumption would therefore be 20m³. Within a PSUT we have to respect the rule that supply equals use, therefore we cannot record that the water supply industry supplies 100 and that agriculture receives 80 [this is because the nature of what a transaction is in national accounts (if I give you 10 dollars, you have to receive 10)]. Therefore, in this case we can either choose to record:

- water industry supplies 100, agriculture receives 100m³;
- water industry supplies 80 to agriculture, agriculture receives 80m³

SEEA(W) and Eurostat opt for the second option and **therefore allocate losses to the supplier** i.e. to the water supply industry (depending on the specific form of the SUT, this could be recorded as a supply of 20m³ from the water industry to the environment).

Coming back to the issue of timing, when we picture losses due to leakages, the intuition may be that this water seeps away to say groundwater resources and therefore does not return to surface water say within the accounting period. This would be the typical example from an arid country. Now if the situation was that this water does not gradually seep to groundwater, but rather flows back directly to the river it was abstracted from, it would be odd to consider it consumed. In that case, the statistical definition would allow recording abstraction of 90 and supply of 80 hence a water consumption of only 10. This is also true if we do not distinguish surface from groundwater, and these timing issues become obsolete.

We therefore propose the following slightly amended definition as Water consumption: "The volume of water used and then evaporated, transpired or incorporated into a product. It also includes water abstracted from surface or groundwater in a catchment and returned to another catchment or the sea or water that is not expected to return to the water body it was abstracted from within the accounting period due to losses."

NB: the definition provided by the SEEA W is a bit problematic in the sense that it calculates water consumption as the difference between supply and use, while according to the supply use logic, supply and use are always equal. The SEEA CF as well as Eurostat (forthcoming) propose a slightly different format of the PSUT and effectively record water consumption as a flow from the economy to the environment.

Eurostat (forthcoming p. 26/27) defines losses as follows:

Losses: irrigation losses, leakage, distribution losses

During distribution of water (between a point of abstraction and a point of use or between points of use and reuse of water) there may be losses of water. These losses may be caused by a number of factors: evaporation when, for example, water is distributed through open channels; leakages when, for example, water leaks from pipes into the ground; illegal tapping when users illegally divert water from the distribution network.

Losses during distribution are calculated as a difference between the amount of water supplied and received therefore they may also include errors in the meter's readings, malfunctioning meters, etc.

Losses in distribution are recorded in the physical supply and use tables as follows:

- *They are allocated to the supplier of water. For example, seepage and evaporation from irrigation canals are allocated to water supply industry, not to the agriculture industry.*
- *Losses due to leakages are recorded as return flow to the environment, mainly as return flow to land (C4).*

- *Losses due to evaporation when, for example, water is distributed through open channels, are recorded as return flow, as evapotranspiration respectively (C5).*
- *Losses due to illegal tapping and malfunctioning metering are included in water abstraction and considered as a flow within the economy.*

2 The treatment of water that is returned to a different river basin.

The second point is that water lost to the sea or another catchment is not considered as 'water consumption' in the SEEAW. In water management, the catchment is generally seen as the appropriate unit for analyzing freshwater availability and use. That is why the water which returns to another catchment or the sea is considered as consumed. This definition is similar to the one used by Eurostat (section 7.1).

This point seems valid and is not necessarily in contradiction with the SEEAW as the SEEAW has a focus on the national level and does not consider PSUTs at catchment level.

3 Contribution from groundwater to the uptake by plants via capillary rise to the rooted soil zone. As already mentioned by Falkenmark and Rockström (2004) who introduced the concept, there is no clear border between green and blue water: groundwater (blue water) can become green water via capillary rise to soil moisture ET (e.g. by crops). Flooding also creates moisture for soil that is relevant for crop production in many areas, and this also turns blue into green water.

Typically, water is separated by the way in which humans use it. and if there is no human interaction we recommend considering the water as green water.

3.1.2 Conclusions

-In the case of green water, we recommend to equate water abstraction with water consumption. This would align the approach taken by Water Footprinting and Eurostat.

-In the case of blue water, there is a need to differentiate between water withdrawal (or abstraction) and water consumption.

-Release of water to freshwater (e.g. after water treatment) is considered negative blue water consumption, since water integrated in products (such as water supplied) is considered to be consumption in the supply industry.

-We propose to include losses in the scope of water consumption, with the conditionality that this covers abstracted water which is not expected to return to the water body it was abstracted from within the accounting period.

-Soil moisture coming from blue water (groundwater by capillary rise or flooding) is considered to be green water.

-We clarified that water abstracted from surface or groundwater in a catchment and returned to another catchment or the sea is also included as water consumption (however this issue may not be relevant when compiling national PSUTs).

-Concerning task 4: we are constrained by data availability and the definitions used in the main data sources; existing data sources may not be aligned with our definition of water consumption for instance due to the exclusion of losses; in the metadata we will be transparent as to the source and underlying assumptions of the data sources used.

3.2 Classifications

- (i) *Supplementary classifications by purpose (e.g. water for cooling) will be proposed as this information is crucial for a better understanding and quantification of environmental impacts.*

The detailing of a set of water PSUTs requires defining a harmonised classification of (economic) activities, i.e. the column headings of the water PSUTs. These activities, can be decomposed into (1) production activities, (2) final use activities, and (3) *Rest of the World* activities. In addition, Eurostat proposed to add (4) the environment as an activity-column.

(1) production activity-columns

For production activities, i.e. industries, the standard classification is ISIC/NACE; here a minimum breakdown level should be envisaged. A reasonable starting point could be to use the level as employed by Eurostat's monetary input-output tables (NACE rev 1.1: A60; NACE rev 2: A64), which also underlies the reporting requirements for other types of environmental accounts (e.g. air emission accounts).

From an environmental perspective particularly when focusing on water use/consumption, the breakdown of the ISIC/NACE system is not specific enough. For example, hydroelectric power generation and the thermoelectric sectors are two important sectors in terms of significant water abstraction and return flows that are not represented separately in the NACE classification. Thus, further disaggregation is necessary for the electricity sector (NACE 35) to cover the water use by hydroelectricity and thermoelectric sectors. Therefore, the PSUTs proposed by Eurostat show a further disaggregation of Electricity, gas, steam and air conditioning supply (NACE 35) as follows:

- Electricity, gas, steam and air conditioning supply (NACE 35)
 - Electric power generation, transmission and distribution (NACE 35.1)
 - Production of electricity (NACE 35.11)
 - Thermoelectric (new code – 35.11a)
 - Hydroelectric (new code – 35.11b)
 - Nuclear (new code – 35.11c)

In addition, other industries could also be further disaggregated, for instance industries that use large quantities of water (e.g. agriculture 70%), or industries that discharge big amounts of wastewater to the environment and are major sources of emissions (e.g. aquaculture, mining, wastewater, etc). However, as the focus is also set on data availability we refrained from introducing more level of detail.

(2) final use activity-columns

In addition to the industries, columns for the final use categories also have to be considered. These encompass “Final consumption by households” and “Changes in inventories”.

(3) Rest of the World (RoW)

In addition to the industries (NACE) and final use categories, the *Rest of the World* is considered as one single activity-column. This column records the imports (Supply table) and the exports (Use table).

(4) Environment

Finally, the Eurostat manual recommends adding the *environment* as an activity-column, in order to use it as an origin and destination of certain water flows (e.g. precipitation, infiltration).

3.3 Integration of blue-green-grey water footprints

(ii) *This task will further analyze to what extent the concept of blue-green-grey water footprints (surface/groundwater – precipitation – polluted water) can be fitted to the existing accounting systems.*

(iii) *Also the feasibility of integrating virtual water trade into water accounts will be assessed.*

The framework of physical Supply and Use tables (PSUTs) constitutes the most suitable conceptual approach to record all water flows entering, flowing within, or leaving the economy in a consistent way. Additionally, the Supply-Use-Tables framework allows for a hydrologically and system-theoretically consistent integration of “blue” and “green” water flows.

Blue water flows are represented as abstraction from inland freshwater resources such as surface water and groundwater, from precipitation, as well as return flows to surface water bodies, to groundwater bodies, to the sea, or to land. Green water flows are represented as abstraction from soil water, product integration and evapotranspiration.

According to the above it is possible to quantify which industry requires how much of which water type for its functioning, and how much of which water type is abstracted and returned to the environment in which type respectively.

Grey water flows can be calculated on the basis of the tables on emission supply and use foreseen in the PSUT set. Building on the waste loads, the quantity of water necessary to dilute the waste water to an environmentally acceptable level can be calculated. Relevant thresholds need to be defined.

The river basin is generally considered as the appropriate scale when analyzing freshwater supply and demand. However, international trade of products and services implies regional transfers of water in virtual form (Chapagain and Hoekstra, 2008), where virtual water is the volume of water that is consumed to produce a commodity (Allan, 1998) and therefore the combination of blue and green water consumption. Therefore, it is important to integrate virtual water flows into water accounts.

Two approaches have been used in integrating virtual water flows into water accounts: bottom-up approaches and top-down approaches. The bottom-up (“virtual water flows”) approach is the most widely used in assessing virtual water flows among countries associated with trade in agricultural and industrial products. In this approach virtual water flow is estimated by multiplying the trade volume (in ton/yr or \$/yr) by the virtual water content or water intensities (in m³/ton or m³/\$) of the traded goods. The water intensities for agricultural products are derived as a ratio of the total water required to produce the product (in m³/yr) to the total production (in ton/yr), or by directly calculating specific crop water requirements. For industrial products the intensities are estimated by dividing industrial water abstraction (m³/yr) by the total value added of the sector (\$/yr). The main disadvantage of the bottom-up approaches is its failure to comprehensively trace the water flows along the full supply chains that are crucial for allocating responsibility to the final consumer (Feng et al., 2011). In most of the studies using this approach, the virtual water flows are traced only to the immediate exporting countries (Hoekstra and Mekonnen, 2012).

The top-down (input-output) approach to integrate virtual water into water accounts provides a complete description of the supply chain. The top-down approach can be further divided into Water Embodied in Bilateral Trade (WEBT) and Multi-Regional Input-Output analysis (MRIO) (Feng et al., 2011; Peters et al., 2011). The Multi-Regional Input-Output (MRIO) analysis is capable of addressing the limitation of the bottom-up approach by comprehensively tracing the water flows along the complete supply chain and making sure that water used in production is assigned to the end-product consumed (Feng et al., 2011; Steen-Olsen et al., 2012). An extended MRIO model has been successfully implemented in the recently completed EXIOPOL (www.feem-project.net/exiopool/) and Open-EU project (Hertwich and Peters, 2010; Steen-Olsen et al., 2012). A higher level of detail was achieved by creating extension matrices for the primary products of agriculture and forestry (see next chapter). The water flows along the full supply chains and the water footprint are calculated by multiplying the final demand for a crop by the crop and country specific water intensities (in m³/\$) (Hertwich and Peters, 2010; Steen-Olsen et al., 2012). In CREEA and the further developed EXIObase, virtual water will be integrated into the water accounts following the same approach using the MRIO model.

Accounting for water flows using a supply use framework as suggested by Eurostat will – once the necessary data are available and the tables are in use – allow for calculating the relevant indicators to be plugged into the MRIO framework – green water consumption and blue water use and consumption. The present task focused on assessing the capability of such an approach. In Task 3.4 we will see that due to data availability for the EXIObase we had to use international databases aggregated to a higher level, in order to come up with data useful to be used as extensions for the MRIO.

3.4 Integration of spatial and temporal aspects

- (i) *Since water has spatial and temporal characteristics, which are usually not addressed in standard statistical accounts, a scheme of how to compile spatially and temporally disaggregated information without disrupting the accounting structure will be elaborated. For different analysis objectives different levels of geographical disaggregation should be applied. Water accounts can be differentiated at the level of administrative regions, river basins or accounting catchments at sub-national level.*

- (ii) *Temporal variation in use-supply accounts will be analyzed for selected sectors of relevance (e.g. agriculture). Using information on seasonal activity patterns of these economic sectors, temporally differentiated data will be estimated. Temporally resolved information on water use and supply will enhance the assessment of environmental impacts being subject to seasonality and thus provide an improved valuation basis.*

Water consumption and related impacts vary greatly in space and time. Since water has spatial and temporal characteristics that are usually not addressed in standard statistical accounts, a scheme to integrate spatially and temporally disaggregated information without disrupting the accounting structure is presented.

For different analysis objectives, different levels of geographical disaggregation should be applied. Water accounts can be differentiated at the level of administrative regions, river basins or sub-national accounting catchments.

The definition of spatial and temporal resolution is a key decision and helps define the system boundary. In the CREEA project, as in statistical accounts, the definition of the spatial units – the national level – is provided, and typically annual time steps are used. In order to integrate higher spatial and temporal resolution without changing the structure of the I/O tables, an intermediate step is proposed: For each region, sectoral, spatial and temporal allocation matrices are used to provide the relevant sectoral, spatial and temporal resolution. This disaggregated data is required for accurate calculations, and its provision in the CREEA deliverables means that the matrices can be later used for further analyzing the results in a disaggregated form. The aggregation and disaggregation matrices also make updating and verifying the data easier.

For practical reasons, we separate temporal and spatial aspects. Since temporal aspects are typically only relevant if also information on higher spatial resolution is available, while higher spatial resolution is also valuable without higher temporal resolution, we first aggregate on annual level and then on the sector-region resolution. For interpretation, this reduces the efforts of disaggregation in cases where low variability in the use patterns occurs. This is the case for many sectors except agriculture. The choice of spatial and temporal resolution is essentially determined by the relevance of impact assessment and currently watershed level and monthly resolution are the state-of-the-art requirements, which lead to detailed allocation matrices.

3.4.1 Integration into existing Supply and Use Tables (SUT)

CREEA has two tables that describe the system model. The supply and use table (SUT) has domestic production, consumption, and trade, and looks like this (Products and industries can also be combined):

	Region 1	Region 2	Region 3
Region 1	Domestic supply/use	Trade from 1 to 2	Trade from 1 to 3
Region 2	Trade from 2 to 1	Domestic supply/use	Trade from 2 to 3
Region 3	Trade from 3 to 1	Trade from 3 to 2	Domestic supply/use

- Domestic supply and use tables are broken down into products and industries.
- Industries produce and consume products.
- Consumers consume products.
- Trade is of products to industries.
- Industries add value.
- In CREEA, each industry produces one primary product. Secondary products, such as waste, may also be produced.
- The units of the flows are USD/EURO.

The domestic supply use table looks like this:

	Products	Industries	Final use
Products	<i>nothing</i>	Use	Domestic consumption
Industries	Supply	<i>nothing</i>	<i>nothing</i>
Value added	<i>nothing</i>	Value added	<i>nothing</i>

Environmental extensions describe the environmental impact of one unit (monetary or physical) of an industry. As such they are linked to industries, not products. The environmental extensions table looks like this:

	Region 1	Region 2	Region 3
Air emissions - rural, low stack	Example Matrix 1	...	...
Air emissions - urban, low stack	...	...	...
...	...	...	...
Land use	...	...	...
Energy use	...	...	...
Energy supply	...	...	...
Water consumption	...	...	...
Biomass resource flows	...	...	...
Economic flows, e.g. taxes	...	...	...
Social flows	...	...	...
Resource consumption	...	...	...

The environmental extensions table includes over 9000 economic, social, and environmental interventions.

	Products	Industries	Final use
NO_x	<i>nothing</i>	kg/unit	<i>nothing</i>
...	<i>nothing</i>	kg/unit	<i>nothing</i>
CO₂	<i>nothing</i>	kg/unit	<i>nothing</i>

The environmental extensions table has a number of rows for water use and consumption, but only at the spatial scale of the CREEA project, i.e. EU-27 plus 16 regions.

We want to provide data for every spatial unit of the original source data and match with the CREEA regions for specific sub-industries (e.g. specific crops). The allocation matrix will map spatial units (e.g. watersheds) directly to CREEA regions by industrial sector:

		Region 1			Region 2		
		Ind. 1	Ind. 2	...	Ind. 1	Ind. 2	...
Spatial Unit 1	Sub- Products 1	A					
	Sub- Products 2	B					
	...		G				
Spatial Unit 2	Sub- Products 1	C			E		
	Sub- Products 2	D	F		F		
	...		H			I	

The values in each table are the share of water consumed for one unit of monetary or physical output of a sub-product in a disaggregated spatial unit by an industry in a CREEA region. For example, the value at point A would represent the water consumption share from watershed 1 of Sub-product 1 (e.g. tomatoes) consumed by industry 1 (e.g. vegetables) in CREEA region 1.

The sum of the values in each column is one. This table is sparse – more than 99 percent of the values are zero – and as such only the nonzero values need to be stored.

The average annual data on water use and supply tend to hide an important characteristic of water resources: its natural temporal variability. Water scarcity and environmental impacts manifests themselves at higher temporal resolution rather than annual scale, due to the intra-annual variations of both water use and supply. Information on water use and supply at higher temporal resolution, therefore, enables a more detailed and improved analysis of environmental impacts which are subject to seasonality. However, temporally resolved data on water use and supply, except for the agricultural sector, is not available for all industries. Therefore, to have a consistent database for all sectors, temporally disaggregated water use and supply data will not be provided.

The temporal aggregation table provides further detail on the water use of sub-product production during the year. For example, A, B & C are the factors for the temporal unit for the sub-product 1, which could be monthly factors for water consumption of wheat. Sub-product 2 might require constant water consumption over time and therefore the same factor ($D=1/12$ for monthly temporal units).

	Spatial Unit 1			Spatial Unit 2		
	Sub-Products 1	Sub-Products 2	...	Sub-Products 1	Sub-Products 2	...
Temporal Unit 1	A	D	...	...	...	...
Temporal Unit 2	B	D	...	...	...	...
...	C	D	...	...	...	...

3.5 Compiling and testing the full set of water accounts for the Netherlands.

Develop a full set of water supply and use tables for the Netherlands using the concepts and definitions outlined in SEEAW and SEEA2012 and the proposed methodological improvements. These accounts will be compiled on a national and regional scale (water basins). The practical problems encountered when trying to make operational the full set accounts will be evaluated and the necessary/feasible level of spatial and temporal disaggregation discussed.

Furthermore, under the European Strategy for Environmental Accounting (ESEA) Eurostat identified NAMEA energy and NAMEA water as areas further priority has to be set on, requiring the development of harmonized accounting tables, etc. In realisation of these priorities project team members of the CREEA consortium (SERI, WI, SCB, Twente) are currently carrying out a project for Eurostat to develop accounting tables for water and energy – the experiences of which have to and will be taken into account into the CREEA works. In particular in

subtask 3 a comparison will be made between the proposed Eurostat table and the SEEA 2012 standard water table and both will be tested

In this section we provide a brief description regarding data sources and assumptions used during the testing exercise of the proposed PSUT. In addition we outline a number of issues that require further discussion or further research. In terms of an outline, we follow essentially the structure of the PSUT. It should be stressed that the results presented here are preliminary.

Comparison between SEEA CF PSUT and Eurostat proposal

The Annex provides the PSUT format for water as recommended in the SEEA CF (UN et al., 2012) as well as the draft Eurostat format. The formats are to a large extent aligned. Both the SEEA CF and Eurostat format are different from the SEEAW on two important respects:

- A column for the environment is provided, whereas the SEEAW did not include this;
- Supply (by industry) equals use, whereas in the SEEAW the difference between supply and use equalled water consumption. In the SEEA CF and Eurostat framework water consumption can be estimated as the sum of particular items within the PSUT

There are also a number of minor differences between the Eurostat and SEEA CF format concerning the various rows.

Table: breakdown of Eurostat format within the economy.

CPA 35	Electricity, gas, steam and air conditioning
CPA 36	Natural water; water treatment and supply services
CPA 36.00.11	Drinking water
CPA 36.00.11	Non-drinking water
CPA X	Water incorporated in products
B.1	Wastewater – treated
B.2	Wastewater - untreated

- The Eurostat format is structured into three blocks (from the environment to economy; within the economy; and from the economy to the environment – this structure resembles the SEEAW format). On the other hand, the SEEA CF format distinguishes 5 main categories: i) sources of abstracted water, ii) abstracted water. iii) waste water and reused water, iv) return flows of water, v) water incorporated into products.
- Regarding water incorporated into products: according to the SEEA CF this is only recorded once as a supply (in fact as part of water consumption) of water, say, by agriculture in the form of products; in the Eurostat format however, water incorporated into products can also be used and subsequently turned into a supply of water (you drink beer which ends up into the sewerage system).
- CPA 35 electricity, gas, steam and air conditioning is not included in the SEEA CF format, but is included in the Eurostat table; no distinction is made between drinking water and non-drinking water.
- In terms of column detail, the Eurostat proposed format contains lots of sectoral detail, whereas the SEEA CF format only focuses on the main aggregates.

As the formats are very similar and the Eurostat format is a bit more detailed (both in sectoral detail as well as treatment of water incorporated into products) we have decided to explicitly test the Eurostat format in this Section.

General remarks

The recently filled Joint Questionnaire on Inland Waters from Eurostat & OECD (a draft version was sent to Eurostat mid-January 2013) and of course underlying data sources on water statistics and water accounts served as a main vehicle to populate the PSUT;

For now, compilation has been done at a national scale, although for some items (primarily abstraction of water) data on a regionalised scale, particularly at (sub-)River Basin scale is available. This is however not the case for the majority of data items;

We have chosen 2007 aligned with the CREEA project.

Water Use Table (T.2); From Environment to Economy:

A.1.1. and A.1.2. Eurostat – OECD JQ-IW, provides (gross) abstractions of fresh groundwater and of fresh surface water separately. This is compiled for national totals and by (main) economic sector, including for agriculture. The underlying data are based upon different sources among others:

- a. Annual Environmental Reports (AERs) for the manufacturing industry, which are the main source of data on environmental pollution (and resource use) in the economy. Results (aggregates) are presented in the national PRTR and used by numerous parties;
- b. Agricultural Census (by LEI);
- c. VEWIN (Association of Dutch Water Companies);
- d. Customer files of the (10) water supply companies;
- e. Production Statistics;
- f. Other statistics, etc.

While the information provides a breakdown by main industries (e.g. agriculture) it is not possible (without modular assumptions) to disaggregate this information further by crop types, for instance.

A.1.3. Abstraction from soil water. There are two data sources here. Firstly, data compiled within Water Footprint exercises (in particular the green water footprint). As a second data source, a Eurostat study on the water balance (Graveland and Baas, 2012), provides precipitation and also (actual) evapotranspiration (ET) assessments for the NL for 2009. Precipitation and ET are provided for the country as a whole and for the different land use categories. Agriculture and a few main crop categories were also distinguished. The assessment of 'actual evapotranspiration' was done for the National territory and for the regional subdivisions, such as the (Sub-)River basins. The assessment was based upon spatially and temporally explicit Remote Sensing data that was obtained from WaterWatch (E-Leaf).

Waterfootprint data per crop (category) was prepared by University of Twente in context of CREEA project. The green WF is water stemming from soil water (precipitation). The distribution by crop can be used to get a proper breakdown of the calculated sum for crops (agriculture) for the country altogether, for some main sectors with annual crops, perennial crops, and partly for animal husbandry, (specialized) animal and plant growing in mixed farms.

It appears that this approach did not cover the full agricultural area of the country. Based upon FAO data approximately 685,000 ha was taken into account. The large area used for animal production, mainly grassland and connected fodder crops used for animal production such as green maize (approximately 1.2 mln ha) was not fully covered.

Therefore, to estimate soil water consumption for grassland and connected fodder crops, we used the results from (Graveland and Baas 2012). In particular, we added the ET from grassland and area forage crops (green maize). For animal husbandry this implies an addition of a significant area of 1,256,000 ha and about 5,088 Mm3 of ET (where we corrected for green water footprint of 'managed grass') just for the 6-month summer period. Another part of the ET for the winter period may even be added. Therefore, our current estimate should be interpreted as a minimum estimate.

Flowers are not included in the Footprint estimates. Furthermore, although there is a difference regarding the resulting evapotranspiration, the WF study has not differentiated between greenhouse and open field horticulture production. All the vegetables produced are considered as produced in open field which might lead to slight overestimation of evapotranspiration.

The category maize or the other primary crops do not include the crops purposely grown for fodder. The fodder crops are all grouped under the managed grass or fodder crops category.

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In the context of the variety of purposes groundwater is extracted for, a conceptual question appeared. The question of whether extractions of groundwater that are just temporary, should be included or excluded from the data. In practice this relates especially to well-point drainage on construction sites. The drained water is normally directly returned to the environment (i.e. surface water). These temporary extractions account for just a small fraction of the total extraction, but in volume are not negligible. These type of extractions occur in only a few industries, mainly in construction and environmental services (sewage treatment and refuse disposal services). These temporary extractions obviously show (much) stronger fluctuations compared to the (more) permanent extractions of groundwater. This distinction may contribute to the understanding of permanent and temporary extractions, as for example ones dealing with seasonal patterns of use over the seasons. So far we have excluded these extractions.

A.2. Precipitation. This covers glasshouse rooftop harvesting and storage (i.e. collection of water from glasshouse roofs stored in basins at individual enterprise level, or eventually collective systems, etc.). We have made an initial estimate based upon approximately 10.000 ha glasshouse in the NL. This area multiplied by approximately 750 m³ storage / hectare (10% out of annual 7,500 m³ / ha total precipitation), is 7,500,000 m³ a / year (average). Herewith, we obtain 7.5 Mm³ / annum as a first approximation;

A.1.3. In the Eurostat / OECD questionnaire (JQ-IW) is asked for item 'Non fresh water sources', including Marine (Sea water) and brackish water. This covers 'Total gross abstraction'. For NL this particularly comprises cooling water for electricity production near marine shore. It also includes a category "desalinated water", however this category is not substantial for the NL.

Boundary issues: soil water uptake in backyards. Strictly speaking, abstraction from soil water by cultivation processes should be taken into account as they are considered to cross the boundary between the economy and the environment. The output from kitchen gardens is included within the production boundary of the SNA. Therefore, strictly speaking also soil water uptake by kitchen gardens should be included as abstraction from soil water. However, other soil water uptake by plants, lawn etc. in private backyards would not be included as these non-produced assets are considered to lie outside the economy. However the distinction will be very difficult to make in practice.

Regarding the area of backyards or (vegetable) garden in the Netherlands there are approx. 4.5 million gardens, an area of 56,000 ha and an estimated 30,000 ha of lawn. This compares to approx. 2 - 3 percent of the agricultural area and may hold similar ET volumes; the percentage dedicated to kitchen gardens will be very small. For the moment we assume that this amount is negligible.

A similar question arises with respect to the area dedicated to nature / landscape conservation. These areas would be considered non-cultivated assets and lie outside the economy. Therefore, ET is without scope.

Hydropower in NL is only obtained from river (flows), as it is quite a flat country. For 2007 a first estimate for the water outflow (and inflow) from hydroelectric power facilities in rivers has been calculated. For 2009 a calculation had been done based upon data from one of the main hydropower facilities in the country, namely Linne aan de Maas with 11.5 MW electric power and 5,913 mln m³ of water a year. The total capacity of these facilities in the NL is 37.3 MW. Combination of data leads to an estimate of: 19,178 mln m³ for 2009; however, as this is so large we have decided not to include these volumes in the PSUT.

Apparently two more recently developed (renewable) energy systems that are starting to be implemented, seem not be covered by the concept of the PSUT. This need not pose big problems as there is hardly any water abstraction involved. These systems are: *A. Firstly*, in recent years a significant number of heat & cold storage systems in conjunction with construction of (predominantly) new buildings has been installed in the country. It implies that (heated or cold) water is pumped from the subsoil (up to 250 meters), the heat (or cold) is abstracted via a heat exchanger and re-injected to the subsoil. Dutch law requires that exactly the same amount of water is injected as was abstracted. *B. Secondly*, in recent years drilling and extracting (geo) energy from the deeper subsoil, up to 2500 meters deep, has started. Also here it is required by law that injected volumes (at least) equals the abstracted volumes of warm water; while conceptually these flows would seem to be in scope of the PSUT, their net effect should be 0.

Water Use Table (T.2); Within the Economy:

CPA 35. Regarding flows of electricity, gas, steam and air conditioning, practically no information could be obtained and compilation was not achievable. For a significant part of the heat / energy exchange no net water flow is needed, as there may be frequent circulation of water with different heat / cold gradients in which the

heat and cold is derived via heat / cold exchangers. This predominantly holds for systems of district heating as well. Such systems indeed exist within the Netherlands, but the physical flows involved are expected to be very small. In many cases no net supply of water is observed.

CPA 36 covers water flows in the economy of 'drinking water' and 'non-drinking water' or 'other water'. These flows predominantly relate to the (public) Water Supply Companies (PWS).

CPA 36. Drinking water: From the aforementioned sources, the use of drinking water by households and the different industries can be derived. Only for the (limited use) of drinking water by the service sectors a direct source is lacking and these flows need to be distributed based on an additional variable such as labor input by industry;

Moreover, for the water supply sector, a comprehensive water balance exists (see annex).

CPA 36. Non-drinking water: non-drinking water (other water) in volume is certainly less significant than drinking water. At the moment we have two data sources here: the VEWIN provides total supply of non-drinking water (62 MM3); the report 'Industrial water in the Netherlands (Industrie water in NL) (REF, Table 1.) provides an estimate of 150 MM3 which would supply low- and high-quality industrial water by (subsidiaries and affiliates of) water companies. We have for now assumed that the difference between 150 and 62 is supplied by manufacturing itself as secondary production on site. Although there is use (and supply) by water companies (and eventually subsidiaries of the water companies), we do not consider this in the PSUT, and we record these flows as net flows.

In 2013 (and 2014) the use of 'non-drinking water' (or 'other water' or 'industry water') will be studied in detail and quantifications will be improved.

Moreover, for some industries the non-drinking water use may be derived from the Annual Environmental Reports (AERs) in manufacturing, where the largest part (if not all) of the non-drinking water is used;

CPA X. For the water incorporated in products we relied upon the CREEA output available from WP 4. In CREEA physical use and supply tables of materials are compiled for the Netherlands. These two matrices which detail supply and use of products by industry are multiplied with a (best possible estimate) vector of water content by (a selection of the most important) product groups / goods categories (GG). In the water balance study for Eurostat we investigated the import and export of water contained by products in detail (including bottled water). Results from this study have been confronted but yield similar results for imports and for exports (30 vs. 28 in the USE table; 45 vs. 30 in the supply table).

B1. Waste water treated One example is a manufacturer of paper and paper products that supplies the UWWTP with already treated water from their own treatment facility (AWZI). As a second example, some waste water treatment installations (UWWTP's) supply treated water to customer industries with required quality (industry water); at the moment we have not been able to quantify these flows.

Companies, mainly (large) manufacturers that run their own waste water treatment facility without exchange of flows with third parties are not quantified in this block of the PSUT;

B2 . Wastewater – untreated. We have quite reliable data about the total amount of water that ends up in UWWTPs (influent). We have assumed an efficiency of 100 % at UWWTPs, and estimated the amount returned to the environment (the effluent) as the amount supplied. We have information that allows a breakdown into different types of recipient water bodies. What is more difficult is that we do not have information that would allow to breakdown the supply of wastewater to UWWTPs by households and different industries. An easy assumption to make is that this supply equals use (minus a fraction that is lost). The difficulty with this assumption however has to do with the treatment of rainwater (run-off) that is mixed with sewerage water. As a result the amounts used by UWWTPs differ from the amounts supplied (net of run-off).

Luckily, we do have micro information regarding the supply of wastewater that is treated on site by large companies from their AERs. We therefore estimate the supply of wastewater into sewerage as a residual: total use – wastewater treated on site – water incorporated into products being produced + water incorporated into products used = supply to sewerage (a similar approach was followed by Statistics Denmark, 2005). Regarding the households, we assume that a certain fraction of final use (10% e.g. because of watering their backyards) is lost. The remainder enters the sewerage system. NB; this analysis can be made slightly more sophisticated in the near future as we know that 0.68 % of households is not connected to the sewerage system but uses own treatment (e.g. septic tanks) before releasing the effluent directly to the environment.

As a result of this calculation, it appears that approximately 280 MM3 out of 1818 MM3 is due to seepage and rain water run-off. NB; these numbers should be still be updated as these were based on 2009 figures.

Additional issues: How should we deal with wastewater in agriculture? I.e. for cleaning of the animal houses, milking parlour, sheds, machinery, and so on. Regarding liquid manure, we have estimated first of all [using a percentage (50%)] the total supply of manure. Subsequently, we have assumed that 10% of this total flow is supplied by animal husbandry to crop production.

Water Supply Table (T.1); From Economy to Environment:

In principle, for each of the activities we have ensured that total supply and use balance. For some industries such as water supply, an additional source exists. Losses in distribution due to leakages are well-known from the VEWIN, the Association of (10) Dutch Water Companies (figure 1). These comprise losses in the chain starting from the volume of produced drinking water and supplied, metered and charged water to their customers. The water supply companies also refer to these losses as 'water not charged' and may include a small volume of stockpiling (5%). The distribution of the losses over receiving water bodies is difficult to estimate.

In addition, losses are also observed in the production processes of Water Supply Companies (PWS) and in the chain starting from abstraction of the 'raw water source' to the stage of actual volume produced drinking water. The volume of production losses in water purification compares to the distribution losses, both close to 5 percent.

For water to sea it mainly applies that (surface) abstracted marine water from sea (predominantly for cooling) is discharged again to sea. Fresh (surface) water abstracted is mainly returned to (fresh) surface water bodies again. Only a tiny amount of fresh abstracted water is discharged to the sea.

Losses from irrigation back to the environment should be included here. A percentage should be taken from the well-known irrigation volumes. The percentage chosen is a bit arbitrary. The amounts of water abstracted for irrigation in agriculture with amounts from groundwater and surface water abstracted are well known, as is the area irrigated. This is known from two sources: from the Farm Accountancy data network (FADN) data collection and reportings² and secondly also (for some years) from the Agricultural Census run by Statistics NL. With the FADN, the sample data is enlarged to national totals with well-established techniques connecting to production in agriculture. This is known on the level of agricultural subsector and for the seven (Sub-) River Basins. The total irrigated water flow is already accounted for (respectively as abstraction from environment to the economy; and evapotranspiration).

Cooling water returns can be based on abstraction data and code of type of discharged water from Annual Environmental reports. The fresh water is taken from the rivers, used for cooling in the facility and returned again. Evaporation is expected to be small as hardly (only very small ones) dedicated cooling installations exist at large scale and discharge shortly follows after the abstraction. Cooling with abstracted surface water is by far the largest category in thermal electricity production. Other important industries are the chemical industry and refineries;

For brackish and marine water abstracted at or near the coast roughly the same applies. Water that is abstracted in (predominantly) electricity production plants is used for cooling and instantly returned to mainly the salty marine waters (hardly to fresh water bodies) without losing much due to evapotranspiration;

Finally the flow to the environment back again via evapotranspiration balances with the water amount that moves from the environment to the economy via evapotranspiration in conjunction with agricultural production, particularly from soil water.

Balancing of the Use table (T.2) and the Supply Table (T.1);

The discharge of waste water treatment plants, the effluent volumes of UWTP's and/or the treatment facilities in the industry do not necessarily match with the inflow, the influent volumes. This should be considered and treated with care. The reason for the imbalance has mainly to deal with the open systems that are used in these facilities, which lead to an exchange of flows with the atmosphere. Inflow via precipitation

² Via FADN recording and reportings on FADN water data to Statistics Netherlands (2012).

3.6 Conclusions

The PSUT format provides a consistent framework for water accounting. It provides a description of all flows of water from the environment to the economy; within the economy, and from the economy to the environment, broken down by standard classifications of economy activity such as ISIC / NACE. Moreover, the PSUT framework allows to integrate blue; green; grey water types in the sense that these types of water flows can be identified with specific (ranges of) cells in the PSUT.

We have tried to bridge the gap between definitions of water consumption used in the statistical and hydrological community. The definitions provided allow integration of statistical data without major issues while being consistent with hydrological terms. The PSUT framework permits the derivation of estimates of water consumption and water use broken down by economic activities. Subsequently, these vectors may be added as environmental extensions to a MRIO table (such as EXIObase) in order to estimate virtual water flows. The PSUT framework is however quite data demanding. In Section 3.5 the PSUT (draft format as provided by Eurostat) has been tested for the Netherlands. The PSUT can be populated reasonably well, although for several flows (e.g. waste water) the data situation is difficult and there is a need to use assumptions. There are also fairly large uncertainties regarding green water consumption estimates. This is an issue which may warrant further investigation. In terms of sectoral breakdown, the testing so far focused on the main industries. A further breakdown towards A64 may be possible, using assumptions (e.g. water use is scaled with employment data or output etc.). Obviously, given that the Netherlands is a data rich environment, this situation may be different from many other countries.

Concerning the integration of data into the EXIObase, the integration of spatial and temporal detail is accomplished by the introduction of an allocation matrix which is applied to the final results to further allocate water use and consumption to specific regions or months, and therefore to apply proper impact assessment. Similarly, allocation matrices help to attribute the water use and consumption to products within a sector (e.g. tomato in the vegetable sector).

Literature

- Allan, J.A. (1998) Virtual water: A strategic resource global solutions to regional deficits, *Ground Water*, 36, 545-546.
- Chapagain, A.K. and Hoekstra, A.Y. (2008) The global component of freshwater demand and supply: An assessment of virtual water flows between nations as a result of trade in agricultural and industrial products. *Water Int.*, 33, 19-32.
- EIM (2009). Industrial water in the Netherlands (Industriewater in Nederland). EIM, Onderzoek voor Bedrijf & Beleid. Zoetermeer, 2 maart 2009.
- Eurostat: <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/>
- Falkenmark, M. and J. Rockstrom (2004). *Balancing Water for Humans and Nature: The New Approach in Ecohydrology*. London, Earthscan.
- Falkenmark, M., & Rockstrom, J. (2006). The new blue and green water paradigm: Breaking new ground for water resources planning and management. *Journal of Water Resources Planning and Management-Asce*, 132(3), 129-132.
- Feng, K., A. Chapagain, Suh, S., Pfister, S. and Hubacek, K. (2011) Comparison of bottom-up and top-down approaches to calculating the water footprints of nations, *Economic Systems Research* 23(4): 371-385.
- Graveland, C., Baas, C. (2012). Improvement of water flows in the National Water Balance; Water Stocks; feasibility of Water Balances per River Basin. Report X, Statistics Netherlands.
- Hertwich, E.G. and Peters, G.P. (2010) Multiregional Input-Output Database: Open-EU technical document, One Planet Economy Network, Surrey, UK, available at: http://www.oneplaneteconomy.network.org/resources/programme-documents/WP1_MRIO_Technical_Document.pdf
- Hoekstra, A.Y. and Mekonnen, M.M. (2012) The water footprint of humanity, *Proceedings of the National Academy of Sciences*, 109(9): 3232–3237.
- Hoekstra, A.Y., Booij, M.J., Hunink, J.C. and Meijer, K.S. (2012) Blue water footprint of agriculture, industry, households and water management in the Netherlands: An exploration of using the Netherlands Hydrological Instrument, Value of Water Research Report Series No. 58, UNESCO-IHE, Delft, the Netherlands
- ISO. (2013). ISO/DIS 14046 Water footprint -- Principles, requirements and guidelines.
- Kounina, Anna, Margni, Manuele, Bayart, Jean-Baptiste, Boulay, Anne-Marie, Berger, Markus, Bulle, Cecile, . . . Humbert, Sebastien. (2013). Review of methods addressing freshwater use in life cycle inventory and impact assessment. *The International Journal of Life Cycle Assessment*, 18(3), 707-721. doi: 10.1007/s11367-012-0519-3
- McGlade, J., Werner, B., Young, M., Matlock, M., Jefferies, D., Sonnemann, G., . . . Gee, D. (2012). Measuring water use in a green economy, A Report of the Working Group on Water Efficiency to the International Resource Panel: UNEP (United Nations Environment Programme).
- Mekonnen, M.M. and Hoekstra, A.Y. (2010) The green, blue and grey water footprint of crops and derived crop products, Value of Water Research Report Series No. 47, UNESCO-IHE, Delft, the Netherlands

- Olsen, T., 2005. Integrated Environmental and Economic Accounts or Water and Waste Water: Denmark 1999-2003. Statistics Denmark.
- Peters, G.P., Minx, J.C., Weber, C.L. and Edenhofer, O. (2011) Growth in emission transfers via international trade from 1990 to 2008, *Proceedings of the National Academy of Sciences*, 108(21): 8903-8908.
- Pfister, S., & Hellweg, S. (2009). The water "shoesize" vs. footprint of bioenergy. *Proceedings of the National Academy of Sciences of the United States of America*, 106(35), E93-E94.
- Ridoutt, Bradley G., & Pfister, Stephan. (2010). A revised approach to water footprinting to make transparent the impacts of consumption and production on global freshwater scarcity. *Global Environmental Change*, 20(1), 113-120.
- Steen-Olsen, K., Weinzettel, J., Cranston, G., Ercin, A.E. and Hertwich, E.G. (2012) Carbon, land, and water footprint accounts for the European Union: Consumption, production, and displacements through international trade, *Environmental Science and Technology*, 46(20): 10883-10891.
- UN (United Nations) (2012a), System of Environmental-Economic Accounting for Water (SEEA-W), ST/ESA/STAT/SER.F/100, Department of Economic and Social Affairs, Statistics Division, UN, New York.
- UN (United Nations) 2012b. International recommendation for water statistics. Statistical papers Series M No. 91 ST/ESA/STAT/SER.M/91, Department of Economic and Social Affairs, Statistics Division, New York.
- UN (United Nations), EC (European Commission), IMF (International Monetary Fund), OECD (Organisation for Economic Co-operation and Development) and World Bank (2009), System of National Accounts 2008, New York.
- UN (United Nations), EC (European Commission), FAO (Food and Agriculture Organisation), IMF (International Monetary Fund), OECD (Organisation for economic Co-operation and Development) and World Bank (2012), System of Environmental-Economic Accounting, Central Framework, New York.
- VEWIN (2007). Water Supply Statistics 2007. Association of Dutch Water Companies (Vewin). Rijswijk. The Netherlands. 31p. Vewin. No. 2008/83/6259.
- VEWIN (Association of Dutch Water Companies) (2012), Dutch Drinking Water Statistics 2012. The water cycle from source to tap, no.2012/110E/6259, pp.89, Rijswijk.

ANNEX

Table 3.5.1 Physical supply and use table for water (cubic metres of water)

Physical supply table for water	Abstraction of water; Production of water; Generation of return flows							Flows from the rest of the world Imports	Flows from the environment	Total supply
	Agriculture, forestry and fishing	Mining & quarrying, Manufacturing and Construction	Electricity, gas, steam and air conditioning	Water collection, treatment and supply	Sewerage	Other industries	Households			
(I) Sources of abstracted water										
Inland water resources										
Surface water									440.6	440.6
Groundwater									476.3	476.3
Soil water									50.0	50.0
Total									966.9	966.9
Other water sources										
Precipitation									101.0	101.0
Sea water									101.1	101.1
Total									202.1	202.1
Total supply abstracted water									1 169.0	1 169.0
(II) Abstracted water										
For distribution					378.2					378.2
For own use	108.4	114.6	404.2		61.2	100.1	2.3			790.8
(III) Wastewater and reused water										
Wastewater										
Wastewater to treatment	17.9	117.6	5.6		1.4		49.1	235.5		427.1
Over-treatment										
Reused water produced										
For distribution					42.7					42.7
For own use		10.0								10.0
(IV) Return flows of water										
To inland water resources										
Surface water			300.0		52.5	0.2	0.5			353.2
Ground water	65.0	23.5		47.3	175.0	0.5	4.1			315.4
Soil water										
Total	65.0	23.5	300.0	47.3	227.5	0.7	4.6			668.6
To other sources		5.9	100.0		256.3		0.2			362.4
Total Return flows	65.0	29.4	400.0	47.3	483.8	0.7	4.8			1 031.0
(V) Evaporation of abstracted water, transpiration and water incorporated into products										
Evaporation of abstracted water	76.2	43.2	2.5		1.8	0.7	10.0			138.0
Transpiration										
Water incorporated into products										
Total supply	267.5	314.8	812.3	489.9	627.3	55.7	250.3		1 169.0	3 986.8

Note: Dark grey cells are null by definition.

Table 3.5.1 (cont) Physical supply and use table for water (cubic metres of water)

Physical use table for water												
Abstraction of water, Intermediate consumption, Return flows							Final consumption	Accumulation	Flows to the rest of the world	Flows to the environment	Total use	
	Agriculture, forestry and fishing	Mining & quarrying, Manufacturing and Construction	Electricity, gas, steam and air conditioning	Water collection, treatment and supply	Sewerage	Other industries	Households		Exports			
(I) Sources of abstracted water												
Inland water resources												
Surface water	55.3	79.7	301.0	4.5	0.1						440.6	
Groundwater	3.1	34.8	3.2	432.9		2.3					476.3	
Soil water	50.0										50.0	
Total	108.4	114.5	304.2	437.4	0.1	2.3					966.9	
Other water sources												
Precipitation				1.0	100.0						101.0	
Sea water			100.0	1.1							101.1	
Total	0.0	0.0	100.0	2.1	100.0	0.0					202.1	
Total use abstracted water	108.4	114.5	404.2	439.5	100.1	2.3					1 169.0	
(II) Abstracted water												
Distributed water	38.7	45.0	3.9			51.1	239.5				378.2	
Own use	108.4	114.6	404.2	50.4	100.1	2.3	10.8				790.8	
(III) Wastewater and reused water												
Wastewater												
Wastewater received from other units					427.1						427.1	
Own treatment	12.0	40.7									52.7	
Reused water												
Distributed reuse												
Own use												
Total	12.0	40.7			427.1						479.8	
(IV) Return flows of water												
Returns of water to the environment												
To inland water resources										668.6	668.6	
To other sources										362.4	362.4	
Total return flows										1 031.0	1 031.0	
(V) Evaporation of abstracted water, transpiration and water incorporated into products												
Evaporation of abstracted water										138.0	138.0	
Transpiration												
Water incorporated into products												
Total use	267.5	314.8	812.3	489.9	627.3	55.7	250.3			1 169.0	3 986.8	

Note: Dark grey cells are null by definition.

Table 1 Draft Water use table Netherlands 2007 (preliminary results)

Country :	CREEA-countries
Year :	2007
Type :	Water Use Table (T.2)
Unit :	Mm3

	Can be filled
	Can be partly filled
	Cannot be filled

Industries (NACE)				1	36	42	67	76	81	85	134	135	136	137
										G-H-I-J-K-L-M-N-O-P-Q-R-S-T-U	Final use			
			Country Total	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Water supply; sewerage, waste management and remediation activities	Construction	Services	Final consumption by households	Changes in inventories	RoW	Environment
Water Flows														
Flow	Code	Label												
From Environment to Economy	A.1	Inland water resources	21.846	7.154	1	3.357	9.389	1.734	484	0	0			
	A.1.1	Surface water	9.900	21	1	2.848	6.067	964	482	0	0			
	A.1.2	Groundwater	982	50	0	161	2	770	3	0	0			
	A.1.3	Soil water	7.076	7.076	0			0			0			
	A.2	Precipitation	8	8	0			0						
	A.3	Sea water	3.881	0	0	348	3.321	0	0	0	0			
Within the Economy	CPA 35	Electricity, gas, steam and air conditioning												
	CPA 36	Natural water; water treatment and supply services	1.235	50	4	335	3	4	2	46	789		3	
	CPA X	Water incorporated in products	104	8	0	33	2	0	6	5	12		30	
	B.1	Wastewater - treated	0	0				0						
	B.2	Wastewater - untreated	1.822	6				1.816						
From Economy to Environment	C.1	Water to surface water bodies											11.028	
	C.2	Water to groundwater bodies											50	
	C.3	Water to sea											4.013	
	C.4	Water to land											53	
	C.5	Evapotranspiration											7.255	
				7.218	5	3.724	9.394	3.554	492	51	801	0	33	

Source: Statistics Netherlands (2013)

Table 2: Draft Water supply Table Netherlands 2007 (preliminary results)

Country : CREEA-countries			Can be filled Can be partly file Assumptions needed Cannot be filled No information; or insignificant	
Year : 2007				
Type : Water Supply Table (T.1)				
Unit : Mm3				

Industries (NACE)			1		36		42		67		76		77		78		79		80		81		85		134		135		136		137	
																									Final use							
			Country Total		A Agriculture, forestry and fishing		B Mining and quarrying		C Manufacturing		D Electricity, gas, steam and air conditioning supply		E Water supply; sewerage, waste management and remediation activities		36 Water collection, treatment and supply		37 Sewerage		38 Waste collection, treatment and disposal activities; materials recovery		39 Remediation activities and other waste management services		F Construction		G-H-I-J-K-L-M-N-O-P-Q-R-S-T-U Services		Final consumption by households		Changes in inventories		RoW	
Water Flows																																

Flow	Code	Label																																																		
From Environment to Economy	A.1	Inland water resources																																																		21.846
	A.1.1	Surface water																																																		9.900
	A.1.2	Groundwater																																																		982
	A.1.3	Soil water																																																		7.076
	A.2	Precipitation																																																		8
	A.3	Sea water																																																		3.881
Within the Economy	CPA 35	Electricity, gas, steam and air conditioning																																																		
	CPA 36	Natural water; water treatment and supply services	1.245	0		88		1.150	1.150	0	0		0	0													7																									
	CPA 36.00.11	Drinking water	1.095					1.088	1.088																		7																									
	CPA 36.00.11	Non-drinking water	150				88		62	62																																										
	CPA X	Water incorporated in products	118	29	7	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1																													
	B.1	Wastewater - treated																																																		
	B.2	Wastewater - untreated	1.542	6	0	735	16	22							22				0	42				721																												
From Economy to Environment	C.1	Water to surface water bodies	11.028	4	-	2.322	6.060	2.142	-	1.677	459	5	492	9	-	-																																				
	C.2	Water to groundwater bodies	50	-	-	-	-	50	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-																					
	C.3	Water to sea	4.013	-	-	554	3.318	141	-	141	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-																					
	C.4	Water to land	53	-	-	-	-	50	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-																					
	C.5	Evapotranspiration	7.255	4	7.174	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-																					
	Totals from use table			7.217	7	3.724	9.394	3.554	1.249	1.818	481	5	492	52	801	-																		52																		
			7.218	5	3.724	9.394	3.554	1.249	1.818	481	5	492	51	801	-																		33																			

Source: Statistics Netherlands (2013)