Book

Water footprint and corporate water accounting for resource efficiency

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THE GLOBAL COMPACT

The CEO Water Mandate

Water Footprint and Corporate Water Accounting for Resource Efficiency

United Nations Environment Programme

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Water Footprint and Corporate Water Accounting for Resource Efficiency

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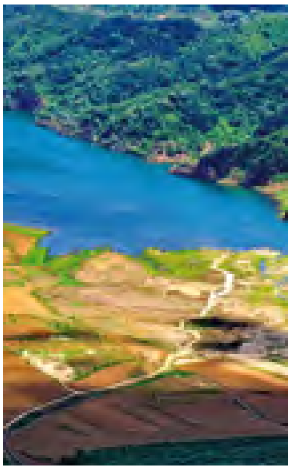
Executive Summary

WATER FOOTPRINT AND CORPORATE WATER ACCOUNTING FOR RESOURCE EFFICIENCY

As water resources are unevenly distributed and, in some regions scarcity and droughts are increasing both in frequency and intensity due to climate change, concerns about them are also becoming more and more important on the international agenda.



In this context, the UNEP project called "Water Footprint, Neutrality and Efficiency" (WaFNE) addresses the growing need to further enhance water efficiency and to improve water quality in a comprehensive way, in water-intensive industries and water-stressed areas, especially in the developing countries.

This report provides an overview on the public and private initiatives as well as methods and tools for water accounting and efficiency worldwide with the aim of raising awareness and enhancing sustainable water management. The report includes three documents developed by UNEP in the area of water footprint and corporate water accounting and disclosure for resource efficiency:

1 **"Water footprint assessment, policy and practical measures in a specific geographical setting".** This technical report, joint effort of UNEP and the Water Footprint Network, presents the first comprehensive overview and analysis of applications of the water footprint assessment in different geographical areas. Next to this, it provides a broad overview of different responses and measures to enhance the sustainability of water footprints across policy sectors at different geographical scales, and a practical guideline for water footprint assessment. The findings provide guidance for using and applying the water footprint in geographical areas to inform integrated water resources management.

2 **"Corporate Water Accounting - An Analysis of Methods and Tools for Measuring Water Use and its Impacts".** This technical report is a joint effort of UNEP and the UN Global Compact CEO Water Mandate with the Pacific Institute, which assesses existing and emerging water accounting methods and tools being used in the private sector, with the goals of elucidating commonalities and differences among emerging methods and practices, identifying gaps and challenges and suggesting where accounting methods might benefit from harmonization and increased field testing.

3 **"Mapping Initiatives on Corporate Water Disclosure".** This short technical paper, joint effort of UNEP, the CEO Water Mandate and the Global Reporting Initiative, provides a cursory mapping of various initiatives working to progress the public disclosure of water-related information in the private sector in 2009. The goal is to bring together the community of initiatives working on corporate water disclosure to build a common view of the needs around disclosure and determine ways to make our collective work most effective.

1

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Water footprint assessment, policy and practical measures in a specific geographical setting

September 2010

UNEP

Water Footprint
NETWORK

Introduction

The study is the result of a grant by the United Nations Environment Programme (UNEP) to the Water Footprint Network as part of the UNEP's umbrella project entitled 'Water Footprint, Neutrality & Efficiency' (WaFNE). The WaFNE project addresses the growing need to further enhance water efficiency and to improve water quality more holistically, by applying two emerging concepts of water footprint and water neutrality in key industrial sectors and within water-stressed areas, and by promoting financing mechanisms to improve water efficiency and quality. The project is entailing the refinement of water footprint and related concepts, as well as pilot applications of the associated methodologies and tools in selected geographical areas and industries.

UNEP requested The Water Footprint Network to do a study on the application of water footprint and related concepts in geographical locations to assist UNEP to implement the project activity on the ground. The application of the water footprint is expected to demonstrate the concepts' applicability in enhancing more sustainable use of water, particularly: (i) improving water efficiency and quality in the demonstration area; and (ii) identifying means to enhance more equitable water access through off-setting methods. The application is expected to generate information on how to develop water footprint concept further particularly to fit developing country context.

Parallel to the study of the Water Footprint Network, UNEP executed two other studies. Firstly, the industry sector focused analysis 'Water Accounting Stocktaking Analysis' that is carried out by Pacific Institute. This analysis will map the state-of-play with regard to water accounting methodologies and supporting tools. And, secondly, the financial sector focused analysis entitled 'Advancing the application of corporate water efficiency, footprint and neutrality concepts: taking stock and defining needs in corporate water disclosure and reporting practice' will be carried out by the Global Reporting Initiative. UNEP ensures coordination among these stocktaking exercises.
As mentioned this report focuses on the geographic application of the water footprint. The report is built up in three parts each addressing a specific set of questions.

Part 1 of the study aims to provide answers to the following questions:

- What are the theoretical fundamentals of the application of the water footprint methodology at specific geographical levels?
- What is the contribution of the application of this methodology to policy development?
- What was the scale of existing applications of the water footprint methodology? For which type of regions the method was applied?
- What are the commonalities, differences, contributions and limitations of the case studies?

Part 2 of the study aims to provide answers the following questions:

- Which sector policies and practical measures at different geographic scales can reduce water footprints or can increase their sustainability
- How can water footprint inform policies and practical measures for sustainable water management
- What are gaps in the current knowledge base?

Part 3 of the study aims to provide answers to the following questions:

- What are the most important findings in part 1 and 2 to inform water footprint assessment in various geographical areas?
- What does a practical guideline for water footprint assessment at for various geographical scales look like?
- What are next research and development steps?

The report concludes with a presentation of the overall conclusions and a discussion.

Part 1: WF application at different geographical scales

1.1. Introduction

1.1.1. The different applications of the Water Footprint concept

The Water Footprint concept was introduced by Hoekstra and Hung (2002) when they were looking for an indicator that could map the impact of human consumption on global fresh water resources. It refers to all forms of freshwater use (consumption and pollution) that contribute to the production of goods and services consumed by the inhabitants of a certain geographical region (Hoekstra & Chapagain, 2008). On one hand, one can talk about the water footprint of a product, which is the amount of water consumed directly (operations) or indirectly (supply chain) to produce the product. On the other hand, one can talk about the water footprint of an individual, which refers to the total amount of freshwater used to produce the goods and services (direct and indirectly) consumed by this individual. In the first case, the water footprint of products; the basic information provided by water footprints (WFs) can be used by the private sector to perform risk assessment, as a planning tool, to identify hotspots in their supply chains or to couple it with tools like LCA methods in order to perform benchmarking of products. In the second case, the WF of individuals or the inhabitants of a given region or country; the basic information provided by WFs can be used by governments, academia, NGO's or other organisations for awareness raising or for understanding changes and trends in consumption patterns as related to water resources. In addition, it can also be used by a third sector, water management, that generally concerns a geographic area. Applying the Water Footprint for water management purposes allows for the comparison of the water footprints of water consuming and polluting production sectors in a certain geographic area with the availability of water in the specific geographical area to inform water management decision making. This is the subject of the report: the application of water footprint for water management purposes at different geographical scales.

The above shows that the Water Footprint thus represents a common language to express water use from the production and consumption perspectives in different contexts.

1.1.2. Water Demand Management (WDM), Water Footprint and Virtual Water

There are typically two potential responses in order to meet the increasing demand of existing water resources; either supply side, meeting demand with new resources, or demand side, managing consumptive demand itself to postpone or avoid the need to develop new access to resources (Butler & Memon, 2006). Only until the recent past, current approaches towards water resource management tended to be "supply-driven", meaning that solutions were oriented towards new water supply projects whenever there was a shortage. This is particularly the case for most developing countries (idem). A shift towards water conservation and water demand management has been recognised as essential for the sustainability of water resources and the environment, as well as economic efficiency and social development.

Brooks (2003) defines WDM as a combination of technical, economic, administrative, financial and social measures to regulate the amount, manner and price in which water is accessed, used and disposed, with the ultimate goal of alleviating pressure on freshwater supplies and protecting quality.

Tools for WDM can be grouped into three broad categories: economic instruments, legislative and institutional instruments and awareness raising and capacity building (ESCWA, 2002). The Water Footprint Methodology applied at a given geographical level (river basin, regional, national or global), is complementary to WDM tools. It provides transparency in water accounting; it includes ALL consumptive uses of water and facilitates the analysis on the sustainability of the Water Footprints. It can therefore inform decision-makers in the evaluation of the efficiency of measures taken.

The concept of Virtual Water was introduced by Tony Allan in the nineties (Allan, 1993), when he studied the possibility of importing virtual water as a partial solution to problems of water scarcity in the Middle East. The virtual water content of a product is defined as the freshwater "embodied" in the product, not in real sense, but in virtual sense. It refers to the volume of water consumed or polluted for producing the product, measured over its full production chain.

The 'virtual-water content of a product' is the same as 'the water footprint of a product', but the former refers to the water volume embodied in the product alone, while the latter term refers to that volume, but also to which sort of water is being used and to when and where that water is being used. The water footprint of a product is thus a multi-dimensional indicator, whereas virtual-water content refers to a volume alone.

The Water Footprint can be regarded as a comprehensive indicator of fresh water resources appropriation, next to the traditional and restricted measures of water withdrawal (Hoekstra et al, 2009). It contributes with the following information:

- Type of water used: Blue (related to fresh surface or ground water), Green (related precipitation stored in the soil as soil moisture) and Grey Water (related to water pollution).
- Spatial and Temporal localisation of the Water Footprints: all components of a total WF are specified geographically and temporally.
- Virtual Water Flows: The virtual water flow between two geographically delineated areas is the volume of virtual water that is being transferred from one to the other as a result of product trade.

This makes the water footprint very different from other indicators and very useful for Integrated Water Resource Management.

1.1.3. The four phases in a water footprint assessment

A WF assessment can be divided into four distinct phases, according to the practical guideline provided by Hoekstra et al (2009):

- Setting goals and scope
- WF accounting
- WF sustainability assessment
- WF response formulation

The process is not meant to be linear nor a strict directive, but it provides an organised framework. Since the WF assessment can be applied for many varied purposes and under different contexts, it is very important to clarify the reasons for undertaking such analysis: a national government may be interested in knowing its dependency on foreign water resources or the sustainability of water use in the areas where water intensive import products come from. A river basin authority may be interested to know whether the aggregated water footprint of human activities within the basin violates environmental flow requirements or water quality standards at any time. The river basin authority may also want to know to what extent scarce water resources in the basin are allocated to low-value export crops. A company may be interested to know its dependence on scarce water resources in its supply chain or how it can contribute to lower the impacts on water systems throughout its supply chain and within its own operations.

According to this guideline, in the phase of WF accounting, data are collected and accounts are developed depending on the scope set. In the phase of sustainability assessment, the WF is evaluated from environmental, economical and social perspectives. In the final phase, strategies or policies are formulated.

For a geographically delineated area, one has to define first of all the area boundaries (catchment, river basin, municipality, province, state or nation) and the field of interest, which can be to analyse the virtual water balance and hence respective increase or decrease of the WF due to exports or imports, analyse the allocation of water resources over different purposes, and/or examine the sustainability of such WFs. The next sections are devoted to the WF accounting and sustainability assessment, whereas Part II of this report focuses on the WF response formulation.

1.1.4. Water Footprint accounting within a geographically delineated area and Water Footprint of a geographically delineated area

In the WF manual, Hoekstra et al (2009) introduce two concepts: The WF within a geographically delineated area, and the WF of the consumption of the people living in a geographically delineated area. Both concepts provide different types of information and are complementary.

The fist one (WF within an area) provides information on the allocation of water resources for different purposes, and is defined as the total freshwater consumption and pollution within the boundaries of the area. The area can be a catchment area, a river basin, a province, state or nation or any other hydrological or administrative spatial unit. This indicator should be calculated when one is interested in analysing sustainability and equity issues of the WF located at the specific area of interest.

The water footprint within a geographically delineated area (WF_{area}) is calculated as the sum of the process water footprints of all water using processes in the area:

$$WF_{area} = \sum_{q} WF_{proc}[q]$$

where $WF_{proc}[q]$ refers to the water footprint of a process q within the geographically delineated area. The equation sums over all water-consuming or polluting processes taking place in the area.

The second one (The WF of the consumption of the people living in a geographically delineated area), named the WF of national consumption when a nation is the geographical unit of interest, is related to the amount of freshwater resources needed to maintain the consumption habits of the habitants of this geographical unit, and can be located inside (internal WF) and outside (external WF) the geographical unit of interest.

The WF within the geographical unit indicates the total amount of water consumed locally (some of it used to produce products that are exported) but does not provide information on how much water coming from outside the region is consumed by the inhabitants of the same geographical unit (water "virtually" imported). On the other hand, the WF of national consumption with its internal and external components indicates the amount of water that is consumed by the inhabitants of the nation, to produce the products and services consumed, produced locally or imported. The WF of national consumption does not give an indication of how much local water was exported in a virtual way.

Therefore, it is interesting to know the "virtual water balance" of a geographically delineated are over a certain period of time. It is defined as the net import of virtual water over this period ($V_{i,net}$), which is equal to the gross import of virtual water (V_i) minus the gross export (V_e) (Hoekstra et al., 2009):

$$V_{i,net} = V_i - V_e$$

A positive virtual-water balance implies net inflow of virtual water to the area from other areas. A negative balance means net outflow of virtual water. The gross virtual-water import is interesting in the sense that importing virtual water saves water within the area considered. The gross virtual-water export is interesting in the sense that it refers to local water resources being consumed by people living outside the area of interest. The water footprint accounting scheme proposed by Hoekstra & Chapagain (2008) represents graphically these concepts (Figure 1.1). If one uses a nation as an example of geographical unit, one can say that the WF of the consumers in a nation ($WF_{cons,nat}$) has two components: the internal and the external WF.

$$WF_{cons,\ nat} = WF_{cons,\ nat,\ int} + WF_{cons,nat,ext}$$

The internal WF of national consumption ($WF_{cons,\ nat,\ int}$) is defined as the use of domestic water resources to produce goods and services consumed by the national population. It is the sum of the WF within the nation ($WF_{area,\ nat}$) minus the volume of virtual water export to other nations insofar as related to the export of products produced with domestic water resources ($V_{e,d}$).

$$WF_{cons,nat,int} = WF_{area,nat} - V_{e,d}$$

The external water footprint of national consumption ($WF_{cons,nat,ext}$) is defined as the volume of water resources used in other nations to produce goods and services consumed by the population in the nation considered. It is equal to the virtual-water import into the nation (V_i) minus the volume of virtual-water export to other nations as a result of re-export of imported products ($V_{e,r}$):

$$WF_{cons,nat,ext} = V_i - V_{e,r}$$

The virtual-water export (V_e) from a nation consists of exported water of domestic origin ($V_{e,d}$) and re-exported water of foreign origin ($V_{e,r}$):

$$V_e = V_{e,d} + V_{e,r}$$

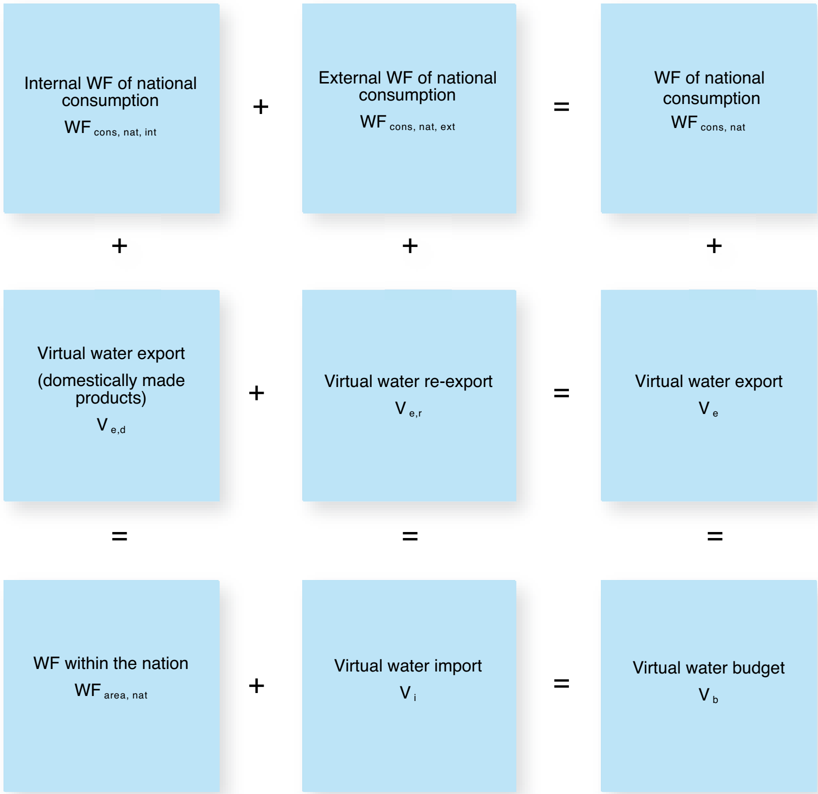

Figure 1.1. The water footprint accounting scheme for a geographically delimited area. The accounting scheme shows the various balances that hold for the water footprint related to national consumption ($WF_{cons,nat}$), the water footprint within the area of the nation ($WF_{area,nat}$), the total virtual-water export (V_e) and the total virtual-water import (V_i). Source: Hoekstra et al, 2009.

Figure 1.2. The Water Footprint Accounting Scheme applied to two nations (nat), The Netherlands (left) and Morocco (right). Sources: Van Oel et al., 2009; Hoekstra & Chapagain, 2007b.

The sum of V_i and $WF_{area,nat}$ is equal to the sum of V_e and $WF_{cons,nat}$. This sum is called the virtual-water budget (V_b) of a nation.

The virtual-water import into a nation will partly be consumed, thus constituting the external water footprint of national consumption ($WF_{cons,nat,ext}$), and partly be re-exported ($V_{e,r}$):

$$V_i = WF_{cons,nat,ext} + V_{e,r}$$
$$V_b = V_i + WF_{area,nat}$$
$$= V_e + WF_{cons,nat}$$

It is important to remember at this point that each one of the elements presented in figures 1.1 and 1.2 are spatially and temporally explicit, and can be presented per type of water: green, blue or grey.

1.1.5. Water Footprint Sustainability Assessment

A water footprint sustainability assessment aims at determining if the water footprints accounted are sustainable in the long term. Ultimately, it refers to the sustainable use of fresh water resources, inviting to reflect on the efficiency and fairness of the existing water footprints. Much has been written about different approaches for quantifying human impacts on water resources. Indicators developed for this quantification may well feed the development of indicators for the water footprint sustainability assessment. This section does not provide a library of indicators for the evaluation of sustainable water resources management; it rather presents the framework in which water footprints can be analysed to assure sustainability.

The Water Footprint Manual (Hoekstra et al., 2009) frames the assessment of water footprints under the following principles:

- water footprints as indicators of water use: water footprints are indicators of actual consumptive water use, as opposed to the traditional indicator of 'water withdrawal', which ignores the fact that part of the withdrawal return to the catchment, and ignores the green and grey components.

- Factors influencing the sustainability of a water footprint: From one side, size, timing, location and colour of the water footprint. From the other side, the context in which this water footprint is located: local conditions as well as the wider context in which the water footprint takes place. A water footprint that is locally sustainable should also be put in a global context, because sustainability is a global issue.

- Accumulated impacts: The impacts of a localised water footprint will always depend on the aggregated water footprints of all activities within a given geographical unit.

- Three pillars of sustainability: water footprints can be analysed from the environmental, social and/or economical perspective (UN, Brundtland commission, 1987). The choice of the three pillars of sustainability suits the purpose of the water footprint as a tool aiming to facilitate the efficient, fair and sustainable use of water resources. But one could use other criteria to do impacts assessments, such as (a) denial of access to water, (b) alteration of water quality, and (c) irresponsible management of water (Wiegand, P., 2009).

- Three types of water: Blue, green and grey water. Water quantity (rain, ground and surface water) and water quality (grey water) are analysed separately.

- Three different geographical scales: micro-level (local), meso-level (river-basin) and macro-level (beyond the river basin). The kinds of questions the sustainability assessment will aim to answer depend on the geographical level of work.

Based on these principles, one can formulate the questions that need to be answered in the sustainability assessment analysis. This will lead to the generation of adequate indicators to solve or provide a measurement that help solving the questions. This framework provides a matrix of critical questions posed when assessing the sustainability of a water footprint (table 1.1).

Table 1.1 Critical questions to be posed when assessing the sustainability of a water footprint[1]

	Environmental perspective	Social perspective	Economic perspective
Micro-level: local	• Does the green water footprint favour production at the cost of valuable natural vegetation and biodiversity? • Does the blue water footprint violate local environmental flow requirements at any time? • Does the grey water footprint violate local ambient water quality standards?	• Does the water footprint deprive other local water users?	• Is the water productivity optimal? • Can water be saved without reducing the production? • Isn't the price of water for the user below its real economic cost, resulting in inefficient use? • Is water scarcity factored in into the decision to consume water?
Meso-level: River-basin	• Does the blue or green water footprint lead to a changed runoff pattern and thus affect downstream environmental flow requirements? • Does the grey water footprint contribute to violation of ambient water quality standards downstream?	• Does the green, blue of grey water footprint affect downstream users without proper compensation or benefit sharing?	• Is the water allocation in time and space over different users optimal? • Are there opportunity costs by not consuming water for another purpose providing more value? • Are there uncompensated external effects on downstream users?
Macro-level: beyond the river basin, global	• Can the water footprint for the given purpose be sustained given the larger context of limited freshwater availability worldwide and other (possibly more important) competing freshwater demands?	• Is it equitable to have this water footprint for the given purpose given the larger context of limited freshwater availability worldwide and other (possibly more important) competing demands?	• Are regional production patterns of and trade in water-intensive products optimal (efficient)? • Are low-value water-intensive products exported from a water-scarce basin?

[1] Source: Water Footprint Manual; Hoekstra et al., 2009.

From the environmental sustainability assessment perspective, Hoekstra et al. (2009) develop detailed guidance and indicators on the hydrological part of the environmental sustainability assessment (water quantity and quality) at the catchment level. Blue and green water scarcity indicators are presented as the water use (blue or green water footprint) divided by the blue and green water availability respectively. This approach is new since: (1) water footprints are used as indicators of water use, i.e., consumptive use of water; and (2) water availability is defined separately for blue and green water (see Annex III -Water Footprint Manual, Box 4.1, 4.2 and 4.3).

From the economic sustainability assessment perspective, the analysis is focused on the economic loss when water productivities are not optimised. Though it is very common to carry out this type of economical analysis, the water footprint manual recommends being very careful before extracting conclusions, because a water re-allocation study should encompass a full economic analysis, and take into consideration non-economic variables as well.

No sustainability assessment indicators are included from the social perspective in the water footprint manual. Nevertheless, issues like equitable sharing, employment and human health are discussed.

1.2. Literature review: existing case studies

After the introduction of the virtual water concept, experts in the field have developed virtual water flow studies for a number of water-scarce regions in the world, at different geographical levels. Examples at the river basin level are the Aral Sea and the Mekong river (Thailand and Vietnam) basins (Nakayama, 2002), the Heihe river basin, (China, Chen et al., 2005), and the Nile river basin (Weyler, E. 2004 and Zeitoun et al., 2010 [1]); at the regional level the SADC countries (Earle & Turton, 2003), the Middle East (Allan, 2003), and at the national level Egypt (El-Sadek, A, 2009), Lebanon (El-Fadel, Maroun, 2003), Jordan (Haddadin, 2003), and Japan (Oki et al., 2003).

The International Expert Meeting on Virtual Water Trade, held at UNESCO-IHE in 2002, condensed the state of the art in this field of expertise, and showed the importance of including virtual water trade analysis in drafting national water policy plans. As a conclusion remark, Hoekstra (2003) states that "virtual water trade should be encouraged to promote water savings for arid countries and at a global level through enhancing food security by appropriate agreements and increasing reciprocity in agricultural products trade…. The total water footprint of a nation promises to become a useful indicator of a nation's call on the global water resources".

Global virtual water flows and analysis were first introduced by Hoekstra & Hung (2002), Hoekstra (2003), Chapagain & Hoekstra (2003) and Zimmer & Renault (2003). In 2004, the first global study including Water Footprint and Virtual Water Trade analysis was published ("The Water Footprint of Nations" Chapagain & Hoekstra, 2004), containing virtual water flows per country related to international trade of crop, livestock and industrial products for the period 1997-2001, and the water footprint of national consumption for almost every country in the world. A refined analysis was presented in the book "Globalization of Water" (Hoekstra & Chapagain, 2008), in which specific case studies are discussed in detail. Water Footprints are presented versus water scarcity, self-sufficiency and water import dependency per country. The figures presented demonstrate the nature of water as a geopolitical resource and urge decision-makers to give priority to this resource in their political agendas.

Several detailed water footprint studies have been undertaken at local levels since 2004, in a first step only by scientists, whereas the interest from the governmental sector has only begun to arise. A comprehensive review of the existing case studies applying water footprint and virtual water trade principles applied to different geographical levels is presented in this section. All the existing studies (to our knowledge) have been collected and analysed. Table 1.2 presents a summary of the existing studies (see Annex I for more details).

[1] Found as the final review of this document was ready. Not included in the analysis presented in this report.

Table 1.2. Studies on the application of the Water Footprint concept at different geographical levels

Geographic unit	Name of the study	Source
Global		
Inter-national	The Water Footprint of Nations	Chapagain & Hoekstra, 2004
	Globalization of Water	Hoekstra & Chapagain, 2008
National		
Indonesia	The Water Footprint of Indonesia provinces related to consumption of crop products	Bulsink et al, 2009
The Netherlands	The external water footprint of The Netherlands: Geographically-explicit quantification and impact assessment	Van Oel et al., 2009
Spain	The Water Footprint of Spain	Aldaya et al., 2008; Garrido et al., 2009.
Germany	The Water Footprint of Germany: where does the water footprint for our food come from?	Sonnenberg et al., 2009
China	Food consumption patterns and their effect on water requirement in China	Liu & Savenije, 2008
	Virtual water versus real water transfers within China	Ma et al., 2006.
India	Going against the flow: A critical analysis of inter-state virtual water trade in the context of India's National River Linking Programme	Verma et al., 2008; Kampman et al., (*in press*)
Cyprus	Virtual water trade and the Water Footprint of Cyprus: alternative tools in managing water resources	Zoumides, C., 2008
Tunisia	A comprehensive water balance of Tunisia: blue water, green water and virtual water	Chaded et al., 2008
UK	UK Water Footprint: the impact of the UK's food and fibre consumption on global water resources	Chapagain & Orr, 2008.
Morocco	The Water Footprints of Morocco and The Netherlands: Global water use as a result of domestic consumption of agricultural commodities	Hoekstra & Chapagain, 2007b
Regional and river basin		
Mancha Occidental Region	Incorporating the Water Footprint and virtual water into policy: reflections from the Mancha Occidental region, Spain.	Aldaya et al, 2009
Doñana Region	Incorporating the Water Footprint and Environmental Water Requirements into Policy: Reflections from Doñana National Park, Spain.	Aldaya et al, 2009
Guadalquivir river basin	Análisis de la huella hídrica de la cuenca del Guadalquivir*	Rodríguez-Casado et al., 2009
Guadiana river basin	Water Footprint analysis for the Guadiana river basin, Spain.	Aldaya & Llamas, 2008
Lower Fraser valley and Okanagan basins	Real and virtual water and water footprints: a comparison between the lower Fraser valley and the Okanagan basin, Canada	Brown et al., 2009; Schreier et al., 2007; Schendel et al., 2007.
Heihe river basin	Water Demand Management: A case study of the Heihe river basin in China.	Chen et al., 2005

* Available only in Spanish

For presenting results, this chapter is divided into four parts, using the framework of the four phases in a WF assessment study as indicated by Hoekstra et al (2009) and presented in the previous section.

In the first part, we present the scope and purposes of the studies. In the second and third parts we analyse the WF accounting and sustainability methods used respectively, depending on the individual context and needs of each study. In the second part, we discuss the strategies proposed for response formulation.

1.2.1. Rationale in Water Footprint and Virtual Water Trade assessment for specific geographical applications: setting goals and scope

The motivation behind each one of the studies changes depending on the context, nevertheless, all the studies are mainly focused in agriculture, which is a logical approach taking into account that agriculture accounts for 86% of humanity's water footprint. Additionally, in one way or the other, all the studies are linked to water scarce regions where agriculture is the main economic activity. Table 1.3 presents an overview of the existing studies, providing a context and the main research questions that were tackled.

> Global

The research done by Chapagain & Hoekstra (2004) and Hoekstra & Chapagain (2008) aims at calculating and assessing the water footprint of nations. For this purpose, virtual water flows between nations are calculated using a top-down approach[2]. The four major factors determining the Water Footprint of national consumption are: volume of consumption (related to the gross national income), consumption pattern (e.g. high versus low meat consumption); climate (growth conditions); and agricultural practice (water use efficiency). Water Footprints are analysed in relation to these factors and in relation to national water scarcity, water self sufficiency and water import dependency. The Water Footprint concept is used as a practical tool to analyse how consumption patterns affect water use, how countries can externalise their water footprint in order to reduce the pressure on the domestic water resources, and how other countries can profit from their relative abundance of water by exporting water-rich commodities.

> National

Three types of studies were found at this geographical level: First, the country has a high external water footprint, low water self-sufficiency (less than 50%) and no substantial internal water scarcity problems. In this kind of studies, the main motivations are to know the water footprint of national consumption through a detailed bottom-up approach[3] and to identify hotspots (places where the external water footprint is significant and/or where the water scarcity is serious). Hotspots are then linked with national trade patterns. This is the case for countries like the UK, the Netherlands or Germany, which face a high virtual water import dependency while at the same time have an interest to identify the spots in the globe where their consumption generates an impact. This is useful information to have in hand when planning future trade strategies.

Second, other countries like China, India, Indonesia, Tunisia and Morocco, have low external WFs, high water self-sufficiency (more than 80%) and face water scarcity problems. Additionally, big countries like China, India and Indonesia have huge internal water availability differences. The motivations for undertaking geographical water footprint studies in these countries vary depending on the context, but it is common to all the need of understanding the logic behind virtual water trade patterns under the water perspective. Studies for China, India and Indonesia are logically based at a provincial level whereas Morocco and Tunisia are based at the national level. Results are afterwards linked to consumption patterns (China), to upcoming National Programmes and infrastructure development projects (India and China) or to population demand (Indonesia).

The third type of study is given by the examples of Spain and Cyprus. They have both internal water scarcity problems as well as a relatively high external WF. At the same time they are export nations in relative terms. Due to its context, its primary motivation lays in performing an internal analysis of the situation, with the ultimate goal of reporting on the allocative efficiency of water and economic resources.

[2] In the top-down approach, the water footprint of national consumption is calculated as the total use of domestic water resources plus the virtual water flows entering the country minus the virtual water flows leaving the country.

[3] In the bottom-up approach, the sum of all goods and services consumed within the nation is multiplied with their respective virtual water content (where the virtual water content of a good will vary as a function of place and conditions of production) in order to calculate the water footprint of national consumption.

> Regional and River Basin

Six studies were found at this level, four for Spanish locations (Guadiana river basin, Doñana region, Guadalquivir river basin and La Mancha region), one for two Canadian basins (low Fraser valley and Okanagan), and one for a Chinese location (Heihe river basin). All the regions suffer of water overexploitation, while at the same time are productive agricultural regions, except for the Doñana river basin, which is an important and protected natural reserve. Therefore the application of the WF methodology is an interesting tool shedding light on key aspects of IWRM in the region.

Table 1.3. Description of existing case studies for the geographical application of the Water Footprint methodology and their motivations1

Geographic unit	Context / Main characteristic	Questions that want to be solved with the studies
Global		
All the countries	Water is unevenly distributed across the globe	- What are the virtual water flows between Nations? - How do these flows relate to national water needs and national water availabilities?
National		
UK	High virtual water import dependency	- What impacts do the UK's consumption patterns have on water resources across the world?
Netherlands	High virtual water import dependencyquantification and impact assessment	- What are the most critical regions of the globe in which the external WF of The NL is located?
Germany	High virtual water import dependency	- Which countries are affected by German virtual water imports and which consequences are derived from that? - Which products have the greatest water consumption?
Germany	High virtual water import dependency	Sonnenberg et al., 2009
China	Huge water availability differences within the country	- How will growing food consumption patterns in China influence water requirements? - Which factors influence inter-state virtual water trade? - How does the South-North water transfer project look like in light of virtual water trade trends?
India	Huge water availability differences within the country in the context of India's National River Linking Programme	- Which factors influence inter-state virtual water trade? - How does the National River Linking Programme look in light of virtual water trade trends?
Indonesia	Huge water availability differences within the country	- What are the virtual water flows between provinces in Indonesia and the relation with food supply / demand at a province level? - How can Indonesian WF be reduced in order to overcome water scarcity competition problems?
Tunisia	Water scarce country	- What are the virtual water flows? - What action plans can be envisaged through the perspective that a holistic water balance offers?
Morocco	Water scarce country	- What are the national WFs and the virtual water flows in and out of the country?

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Continued

Geographic unit	Context / Main characteristic	Questions that want to be solved with the studies
Spain	Water scarce country, high external WF, high food exports	- What are the economic implications of the water allocation in Spain? - Should the paradigm of water scarcity in Spain and most semi-arid countries be readdressed? - How can regional water conflicts be explained in light of these concepts? - What role do water markets play?
Cyprus	Water scarce country, high external WF, high food exports	- What are the policy implications of the actual WF and virtual water flows in the country?
Regional or River Basin		
Guadiana river, Spain	Overexploitation of the aquifer, important agricultural area.	Are trade strategies and agricultural patterns optimal from the water efficiency and economical points of view? How to provide more water for ecological services in the basin?
Guadalquivir river basin[2], Spain	Little rainfall, overexploitation, important agricultural area.	What solutions could be proposed aiming at achieving an agriculture which is more compatible with available resources and the environment?
Doñana river basin, Spain	Important ecological reserve (wetland), national natural park Okanagan basin, Canada	What are the environmental water requirements from the ecosystem perspective? Is the wetland receiving the water it requires in view of the regional water footprints taking place?
Heihe river basin, China	Water scarce, important agricultural area.	Are trade strategies and agricultural patterns optimal from the water efficiency and economical points of view? How does water pricing affect trade patterns as related to water availability?
La Mancha region, Spain	Water scarce, important agricultural area.	- What are the connections between water use, food production and environmental management in this region?

[1] For a more detailed description of the studies, see Annex I.
[2] Study available in Spanish only.

1.2.2. Accounting Methodology

BOTTOM-UP AND TOP-DOWN APPROACHES

Bottom-up and top-down approaches are methodologies developed by Chapagain & Hoekstra (2004) and Hoekstra & Chapagain (2008) in order to calculate the water footprint of national consumption. The bottom-up approach considers the sum of all products consumed multiplied with their respective product water footprint. In the top-down approach, the water footprint of national consumption ($WF_{cons,\ nat}$) is calculated as the total use of domestic water resources ($WF_{area,nat}$) plus the gross virtual water import (V_i) minus the gross virtual water export (V_e) (Hoekstra et al., 2009):

$$WF_{cons,nat} = WF_{area,nat} + V_i - V_e$$

The calculation of the total use of domestic water resources ($WF_{area,nat}$) has been explained in the previous section.

In order to calculate the water footprint of national or regional consumption, the global study considered in this report, as well as the studies for Morocco, Spain and Cyprus, use the top-down approach. The total use of domestic water resources is calculated as total crop evapotranspiration (all crops cultivated within the country) plus domestic and industrial water uses. These studies used water withdrawals as water uses, assuming that from the water withdrawal, some is evaporated (blue WF) and some is polluted but treated to in-stream standard levels (grey WF) (Van Oel et al., 2009).

Both the Spanish and Cypriot studies state that the top-down approach fits them better because of the kind of readily available data sources and because this approach provides direct connections with water, agriculture and trade policies. The studies for the Netherlands, the UK and Germany use the bottom-up approach (except for industrial water footprints, for which the top-down approach is used).

The Water Footprint Manual (Hoekstra et al., 2009), states that the bottom-up and top-down calculations theoretically result in the same figure, provided that there is no stock change over a year. The top-down calculations can theoretically give higher or lower results if the stock of water intensive products increases or decreases respectively over the year. In other words, the balance proposed in the top-down approach does not take into account changes in the virtual water stock. Another drawback of the top-down approach is that there can be delays between the moment of water use for production and the moment of trade (e.g. beef or leather products traded in one year which originate from water used to grow feed crops in the previous year). As a result, the balance presumed in the top-down approach will hold over a period of a few years, but not necessarily over a single year.

Additionally, differences between the two approaches can result from the use of different types of datasets for the calculations. The bottom-up approach depends on the quality of consumption data, while the top-down approach relies on the quality of trade data. When the databases are not consistent with one another, the results of both approaches will differ. When the import and export data of a country are large relative to its domestic production, which is typical for relatively small nations specialised in trade, the top-down approach can be very sensitive to relatively small errors in the input data. This case is shown in the example for the Netherlands (Van Oel et al., 2009). The comparison between the two approaches shows that relative small errors in the estimates of virtual water import and export translate into a relatively large error in the water footprint estimate. In such a case, the bottom-up approach generates more reliable results. Furthermore, in nations where trade is relatively small compared to domestic production, the reliability of the outcomes of both approaches will depend on the relative quality of the databases used for each approach.

INVENTORY BOUNDARIES

The definition of inventory boundaries is the first step of the accounting methodology, and will depend on the goals and scope of the study. Inventory boundaries are described generically by Hoekstra et al (2009) for a given water footprint accounting. Herewith they are presented for the specific application of the water footprint methodology at geographical levels, based on results obtained from the literature review (Annexes I and II).

> What processes should be taken into account?

The agricultural (crop and livestock products), industrial and domestic sectors encompass all the water demands within an economy. Water managers can choose to focus only in agriculture, because the consumption of industrial products is very low comparatively (like in the case of Indonesia), or because food-security issues are their main concern (China and India). One can choose as well to focus only on crops because livestock products consumption is low like in the case of India.

> What types of water footprints are analysed?

Blue water is related to surface freshwater resources, green water to water stored in the soil as soil moisture and grey water is related to pollution. Ground and surface water can be differentiated in the blue component. Is the blue water distinguished between ground and surface water? Do we count on enough data for an accurate calculation of the grey water component?

The majority of the studies reviewed do not include grey water analysis. Though recognised as an important part in the water footprint assessment, it is left out of the scope of the study, like in the Spanish cases. Other countries like the Netherlands, the UK and Germany, did a first rough analysis of their external water footprints and subsequently included the grey water component for the main products imported to the country (and main hotspots).

The study for Indonesia includes the grey water footprint calculation for crops, finding that this component varies between provinces for the same crop, because of different yields.

> Which components of the water footprint are analysed?

Are the external and internal water footprints calculated? At which level of detail? - One can assess in detail the external (part of the water footprint located in other regions or countries in the world) water footprint, like in the case of the Netherlands, the UK or Germany, or the internal water footprint of the region, like in the cases of Spain and Cyprus.

> Are virtual water flows included and at which geographical level?

A nation can be interested in inter-provincial (India, China, Indonesia) and/or international virtual water flows (The Netherlands, the UK, Germany, etc). Guadiana river basin and La Mancha region studies include virtual water flows in the analysis.

> What period of data and which temporal scale?

The time of period chosen depends on the scope of the work and data availability. The water footprint can vary from one year to the other, since climatic conditions change from one year to the other (for example, the blue water footprint will be higher in dry years). This is shown in the Guadiana river basin and La Mancha studies, which analyse three different hydrological years, and in the Cyprus study. On the other hand, if the goal is to analyse changes in consumption patterns or the water demand, a rather long period of time is preferred, like in the case of China (1961-2003), Tunisia (1997-2001) or Spain (1997-2005).

Hoekstra defines three levels of spatio-temporal explication in water footprint accounting: (i) the global level, using an annual resolution, (ii) the national or regional level, using annual or monthly resolutions, and (iii) the local level, using monthly or daily resolutions. All the studies analysed use an annual resolution.

> Water Footprint accounting scheme

The elements of the water footprint accounting scheme presented in the first section of this report are comprehensive and take into account all the possible uses of water at a specific geographic location. The studies analysed in this review do not necessarily take into account all the elements proposed in the accounting scheme, but choose some depending on the goals of the study.

One can be interested in assessing the total water use by a country, including own and foreign resources (water footprint within the area of the nation plus virtual water import), which corresponds to the virtual water budget V_b (see first section). This is the case presented in the study for the Netherlands. Using the data presented in the global studies "The Water Footprint of Nations" and "Globalization of Water", one could estimate V_b for the countries included in the analysis.

Annex II presents a summary of the application of the aspects mentioned above to each one of the studies analysed.

AGRICULTURAL AND INDUSTRIAL PRODUCT WATER FOOTPRINT ACCOUNTING

The methodology to calculate the water footprint or virtual water content of an agricultural product is firmly established and well described in the scientific literature by Allan (1993, 1998a, 1998b), Hoekstra & Hung (2002), Chapagain & Hoekstra (2004), Hoekstra & Chapagain (2008) and Hoekstra et al., (2009). All the studies reviewed in this report apply this methodology for the estimation of the virtual water content of crop and livestock products in both the top-down and bottom-up approaches. It is basically conformed by two steps:

a. Identification of main agricultural products (crops and/or livestock) consumed (for the bottom-up approach) and/or produced (for the top-down approach) within the region of interest.
b. Calculation of the virtual water content of crops and/or livestock products (m^3/ton) using the climatic parameters at their production site.

The estimation of the water footprint of industrial products is more complex since they can be very heterogeneous and require numerous manufacturing processes (Van Oel et al., 2009). The best available methods (Chapagain & Hoekstra, 2004) are based on the industrial value added per product per unity of water used. Since industrial production is generally expressed in monetary terms, it is easiest to consider water use in a sector per monetary unit as well. The water footprint of industrial products estimated in the studies for the Netherlands, the UK and Germany are top-down calculations and make no distinction between different types of commodities. Only the Spanish study distinguishes between 11 industrial sub sectors. However, all the studies undertaking industrial water footprints analysis acknowledge that the industrial water footprint is small in comparison with the agricultural water footprint.

Table 1.4. Impact assessment indicators used in the case studies

Indicator	Unities	Outcomes	Case studies
Environmental			
Competition level (Falkenmark, 1989)	cap/m^3	Population to total runoff ratio	Netherlands
Water stress (Alcamo et al., 2000, 2002)	dimensionless	Water withdrawal to water availability ratio	Netherlands
Water stress (taking into account EFR) (Smakhtin, 2004a, 2004b)	dimensionless	Water withdrawal to water availability ratio taking into account environmental flow requirements.	Netherlands, UK, Germany
Water availability per capita (Verma et al., 2009)	m^3/cap	Available green, blue (internal & external) and total water availability per person living in the geographical unit.	India, Netherlands
Water scarcity (Hoekstra & Chapagain, 2008; Hoekstra et al., 2009)	dimensionless	Water Footprint to water availability ratio.	Global, India
Economic			
Water productivity (expressed in terms of yield)	ton/m^3	Uses of water as related to crop Yield.- How does the South-North water transfer project look like in light of virtual water trade trends?	India, Spain.
Agricultural economic productivity	US$/ha, €/ha	Agricultural economic productivity per crop of irrigated and/or non-irrigated agriculture	Guadiana river basin, la Mancha region, Spain.
Economic water productivity (irrigated and rain-fed crops)	US$/m^3, €/m^3	Economical benefit from crops, interesting when analysed together with the WF of crops.	Heihe river basin, Guadiana river basin, la Mancha region, Spain, Guadalquivir, Doñana, Okanagan & Lower Fraser Valley.
Social			
WF per capita (Chapagain & Hoekstra, 2004)	m^3/cap/yr	Water use by people related to their consumption patterns	All except Heihe river basin.
Energy water productivity	kcal/m^3	Human nutritional benefits per unity of water used.	China
Jobs	number	Number of jobs total or per meter cube	Guadiana river basin, Spain

1.2.3. Sustainability Assessment

None of the case studies analysed in this report follow completely the WF sustainability assessment guidelines proposed by Hoekstra et al. (2009). This is not surprising considering that these guidelines are new and more research is needed for some aspects. Nevertheless, all the studies address the issue of sustainability of the water footprints in a qualitative or quantitative way. Some of the studies use the WF accounting figures (and their temporal and spatial location) as supporting information to question the sustainability of the same figures under a given context, such as in the case of Tunisia, Morocco or the Heihe river basin (China).

Some of the case studies undertake a water footprint impact assessment using indicators to measure different impacts. They are chosen on the basis of the specific interests of the studies. The purpose of the application of such indicators is to contribute to a better understanding of the situation, contributing with new elements that help in the quantification of the efficiency of reduction measures. Table 1.4 presents a compilation of the water footprint impact assessment indicators that were used in the case studies analysed.

Instead of using indicators, other case studies such as the ones for the Okanagan basin (Canada), the Doñana National Park (Spain), and the national study for Tunisia, assess quantitatively the sustainability of water footprints. They do a blue water balance of the region, calculating total blue water available and comparing it to total blue water being appropriated by humans, e.g. water footprints of the different processes taking place at the region of interest. The ratio between these two figures (total blue water footprints to actual blue water availability) would be equivalent to the blue water scarcity indicator proposed by Hoekstra et al. (2009) in the water footprint manual, when (i) environmental flow requirements are taken into account and (ii), blue water appropriated for different processes by humans at the same location are expressed as water footprints and aggregated into a total number.

The following sections present these two types of sustainability assessment.

USE OF IMPACT ASSESSMENT INDICATORS

Environmental indicators

The environmental impacts of the footprints are evaluated in the case studies using indicators that aim at comparing the total use of water (within the region) with a measure of the water actually available for use. These concepts have evolved in the scientific community, from Falkenmark (1989) defining a “competition level” indicator as the population of an area divided by total runoff in that area, to Hoekstra et al., (2009), defining water scarcity from the consumption perspective, as the total water footprint (blue or green) in the geographical region of interest divided by the water availability in the region. In the last case, water availability is defined as total runoff minus the environmental flow requirements.

Most of the case studies use the approach proposed by Smakhtin (2004a, 2004b) for assessing water scarcity. In the case of the UK, Germany and the Netherlands, the impact assessment approach consists in the superposition of the external water footprint of these countries, depicted in a world map, with the water scarcity indicator world map. The detection of hotspots is done by identifying countries where there is a high external water footprint and high water stress.

The water availability per capita indicator (calculated as the total runoff divided by population) is used in the study for the Netherlands as one of the methods to assess their impact on external water resources. In the case of India, this indicator is used at a province level, and green and blue water availabilities are distinguished. Additionally, blue water availability is divided into “internal” and “external” (origin in other states or countries). The level of detail of the studies for the Netherlands and India correspond to the geographical scale and goals of the studies.

Hoekstra et al. (2009) argue that water withdrawal is not the best indicator of water use when one is interested in the effect of the withdrawal at the scale of the catchment as a whole, because water withdrawals partly return to the catchment. In line with this, the water scarcity indicator related to water consumption of the inhabitants of a given region (Hoekstra & Chapagain, 2008) has been applied in the global studies and in the study for India. In these cases, the Water Footprint of national consumption (or regional in the case of the Indian states) is divided by water availability. Water availability is defined as the total renewable water resources, as defined by the Food and Agriculture Organisation in their AQUASTAT database. In the water scarcity indicator proposed by Hoekstra et al. (2009), water availability is defined as the Runoff minus the Environmental Flow Requirements (water needed to sustain a healthy ecosystem).

Economic indicators

FAO (2010) defines "water productivity" as an efficiency term quantified as a ratio of product output (goods and services) over water input. The output could be biological goods or products such as crop (grain fodder) or livestock (meat, egg, fish) and can be expressed in terms of yields, nutritional value or economic return. The output could also be an environment service or function. Water productivity can be at different scales and for a mixture of goods and services.

Yield- water productivities (ton/m^3) are the inverse of product water footprints. They can be used to calculate the economic loss by not using the best technology available when taking into account the potential and actual productivities. This indicator has been applied by the case studies of India and Spain. In the case of India, the example of milled rice grown during kharif is analysed for several states. Potential yield- water productivities for milled rice are calculated for the states where agricultural practices have not been optimised. Increasing water productivities (and therefore reducing virtual water content) for milled rice would decrease the need of rice imports in these states.

In the case of Spain, water productivity in many areas of the economy is already high. In this sense, Spain has already largely adopted the "more crops and jobs per drop" paradigm, but it struggles to achieve the new goal of "more cash and nature per drop".

Agricultural economic (US$/ha, €/ha) and water economic (US$/$m^3$, €/$m^3$) productivities are used in the Spanish studies and in the Heihe river basin study. In the case of the Guadiana or Guadalquivir river basins for example, some regions produce high virtual water content and low blue economic value crops, therefore having low blue economic water productivity. Other regions produce crops with a higher blue economic water productivity. Although one should consider other factors in the analysis, the blue economic water productivity results are interesting when proposing water footprint reduction measures for this semi-arid region.

The Heihe river basin study uses the economic water productivity to analyse possibilities of reduction of the pressure on the scarce water resources of the basin without decreasing the economical income.

Social indicators

The four major factors determining the water footprint of the population of a country are (i) volume of consumption (related to the gross national income), (ii) consumption pattern (e.g. high versus low meat consumption), (iii) climate (growth conditions), and (iv) agricultural practice related to water use efficiency (Chapagain & Hoekstra, 2004). The water footprint per capita is put as a social indicator because, when compared between nations, it gives a notion of the equitability and sustainability of the world's natural resources (Hoekstra & Chapagain, 2008). It would be impossible for every citizen in the world, to develop a water footprint the same size of the average US citizen under current production conditions. In the case of China, the water requirement for food is still much lower than that of many developed countries, although it is currently steadily increasing because of change in consumption patterns (people eating more meat). This will put more pressure on China's already scarce water resources (Liu & Savenije, 2008).

The Spanish case study compares its national water footprint to the global average (1100 m^3/cap/yr to 1300 m^3/cap/yr respectively), and the recommended human food supply, which is 3000 kcal/cap/day out of which 20% are animal products. They conclude that Spain is going to the right direction with this respect.

The energy-water productivity is an indicator that shows how much kilocalories are produced per cubic meter of water used and per type of food. The Chinese study (Liu & Savenije, 2008) shows that meat provides less kilocalories per cubic meter of water when compared to other crops like for example wheat or rice. This indicator is interesting when analysing future trends in consumption patterns.

WATER MASS BALANCE IN THE SUSTAINABILITY ASSESSMENT OF WATER FOOTPRINTS

Some of the studies analysed develop a comprehensive water balance in which all water demands (expressed as water footprints) within a given geographical region are calculated and (in most of the cases) analysed in light of the water availability within the same region. The studies are Okanagan basin in Canada, the Doñana national park region in Spain, the Guadalquivir river basin in Spain, the Guadiana river basin in Spain and the national study for Tunisia.

Although water footprints within a given region and water availabilities in the same region are intrinsically the same information needed for the calculation of the water scarcity indicator proposed by Hoekstra et al. (2009); the main interest with the "comprehensive water mass balance" consists in keeping the different elements of the water footprint accounting framework (see section 1.1.4) and the different colours of the water footprints (green, blue and grey) disaggregated by type of process (e.g. domestic, industrial, agriculture, etc). In line with this, virtual water trade in the region would be included in the analysis. In view of the actual water availability, one can thus develop a meticulous sustainability assessment for each one of the disaggregated water footprints and virtual water flows.

It is interesting to note that Okanagan, Doñana, Guadiana and Guadalquivir basins are important agricultural regions, and as expected, agriculture consumes the biggest proportion of water. Though Okanagan is recognised as a water-abundant region, its distribution is temporally uneven, having abundance in winter and minimal rain in summer, which implies high irrigation requirement during this season. It is also an important golf region, requiring irrigation for the golf courses between March and November. Although total human appropriation of blue water does not surpass blue water availability, it is relatively close (about 90%). Moreover, the analysis is thought to be conservative because industrial and commercial uses are not taken into account. Environmental flow requirements neither. Groundwater and reservoir storage should be included as well in the water balance.

On the other hand, Doñana is a natural reserve. If the wetlands in this reserve are to be protected, environmental flow requirements should be strictly respected here. Results from Doñana show that current amounts of water used in the region do not leave enough water to sustain the wetland's requirements in the long term, even if the region is a protected area.

Guadiana and Guadalquivir are vulnerable river basins due to overexploitation of resources. Although there is no comparison with water availability for the Guadiana basin, the analysis brings out new and clear information on water allocation. The river basin is divided into four main regions (upper, middle, lower Guadiana and TOP domain) and important conclusions are provided in the comparison of sustainability indicators between regions: In the Upper and Middle Guadiana basins, high virtual-water low-economic value crops are widespread, particularly cereals with low economic productivity of the blue water inputs. In particular, the upper Guadiana basin is among the most significant in Spain in terms of conflicts between agriculture, with almost no food (virtual water) import, and the conservation of rivers and groundwater-dependent wetlands. On the other hand, in the Lower Guadiana basin and the TOP domain, vegetables and crops under plastic greenhouses are grown for which the economic productivity of the blue water inputs are much higher, using both surface and groundwater resources. The Guadiana basin has already moved into the direction of "more crops and jobs per drop". The aim is now to move towards "more cash and nature per drop", especially in the Upper and Middle Guadiana basin (Aldaya & Llamas, 2008).

In the case of the Guadalquivir river basin, the situation is very similar to the Upper and Middle Guadiana. Most of the water is used for irrigation of crops which have medium to low economic value (< 0.4 Euros/m^3). They conclude that: "The consumptive use of water in the river basin is very high, which makes the region very vulnerable to droughts, affecting the supply capacity to fulfill all water demands. A better economical, social and environmental allocation of water resources in the basin seems to be necessary" (Rodríguez-Casado et al., 2009; translated from Spanish).

The comprehensive blue water mass balance included in the Tunisian case study is represented through an equation which is used to evaluate future projections of water demands at n years from now. Since Tunisia is a water scarce country, the limiting factor here is the amount of water available for supply, and therefore the authors conclude that the increase in water demands expected with the years (due to increase in population and food consumption, and change in consumption patterns) should be managed by adjusting other elements in the equation, e.g. increasing virtual water imports, decreasing blue virtual water of products produced in Tunisia through technological improvements in agriculture and irrigation, etc. Additionally, based on this analysis the study concludes that in order to assure food security for the country, suitable policies for management and control of food demand evolution should be developed.

Table 1.5. Elements of the water mass balance presented in different water footprint geographical studies

Doñana (Spain)

Processes	Blue WF			Green WF
	Goundwater	Surface	Total	
Crops	Y	Y	Y	Y
Livestock / Fodder	NA	NA	NA	Y
Domestic	Y	Y	Y	NA
Industrial + commercial	Y	Y	Y	NA
Others	NA	NA	NA	NA

Water availability and Environmetal Flow Requirements:
Blue EFR determined by WWF using the ELOHA approach (Poff et al., 2009); green EFR determined using Cropwat. Water availability as determined by Custudio et al. (2006) is compared to total water footprints.

Okanagan (Canada)

Processes	Blue WF			Green WF
	Goundwater	Surface	Total	
Crops	NI	Y[1]	NI	NI
Livestock / Fodder	NI	Y[1]	NI	NI
Domestic	NI	Y	NI	NA
Industrial + commercial	NI	NI	NI	NA
Others	NI	Y	NI	NA

Water availability and Environmetal Flow Requirements:
Water availability is calculated as water storage in the watershed portion of the Okanagan lake and reservoir, and compared to total water footprints. EFR are aknowledged but not included in the balance.

Guadiana (Spain)

Processes	Blue WF			Green WF
	Goundwater	Surface	Total	
Crops	Y	Y	Y	Y
Livestock / Fodder	Y	Y	Y	Y
Domestic	NI	NI	Y	NA
Industrial + commercial	NI	NI	Y	NA
Others	NA	NA	NA	NA

Water availability and Environmental Flow Requirements:
Not included in the analysis

Guadalquivir (Spain)

Processes	Blue WF			Green WF
	Goundwater	Surface	Total	
Crops	Y	Y	Y	Y
Livestock / Fodder	NI	NI	Y	Y
Domestic	NI	NI	Y	NA
Industrial + commercial	NI	NI	Y	NA
Others	NA	NA	NA	NA

Water availability and Environmetal Flow Requirements:
Water availability and Environmental flow requirements data taken from the Spanish Ministry of Environment. EFR data are questioned since the number seems small when compared with the data calculated for Doñana national park (using the ELOHA approach) with is the reciving body from the Guadalquivir. Total Water Footprints are compared to total availability.

Tunisia[2]

Processes	Blue WF			Green WF
	Goundwater	Surface	Total	
Crops	NI	NI	Y	NI
Livestock / Fodder	NI	NI	NI	NI
Domestic	NI	NI	Y	NA
Industrial + commercial	NI	NI	Y	NA
Others	NA	NA	NA	NA

Water availability and Environmetal Flow Requirements:
The report states: The mean water resources of Tunisia from precipitation are estimated at 36 billion m^3/year. The hydraulic resource potential is 4.7 billion m^3/year, including 2.7 billion m^3 of surface water and 2.0 billion m^3 of ground water. Based on this potential, the regularized and effectively exploitable part reaches 3.1 billion m^3/year. 0.7 billion m^3/year are attributed to the environement and water bank (storage in dams for droughts). A long term equation is formulated for the water balance, in shich water supply is the limiting factor.

[1] Total Crop Evapotranspirations are used for the calculation of the Crop Water Footprints (aggregated blue and green crop WFs). Nevertheless, the mass balance in the region is done only for blue water, total irrigation water included.
[2] This case study includes a comprehensive virtual water budget analysis and formulates equation for the long-term blue water mass balance.
NI: Not included
NA: Not applicable

Table 1.5 summarises the processes included in the case studies which developed a comprehensive water balance. Despite the fact that there are some research gaps, the analysis proves to be useful because one can weigh the appropriation of water for different uses, and compare it to the actual water available for human appropriation, acknowledging that flows needed to maintain ecosystems should be respected.

1.2.4. Response formulation

Tables 1.6 and 1.7 present a summary of the response options proposed by the case-studies. Many actions can be proposed in the response formulation phase (see Part 2 of this report), however the challenge here consists in formulating the "right actions" to improve the current situation, in light of the new information conveyed by the WF data, while at the same time taking other factors into account (land availability, labour, political issues, etc). The "right actions" would lead here to an overall decrease in total WF values and/or their localised impacts.

The formulation of response options is related to the scope and goals of the studies. The most common options proposed are:

- Improvement of water productivity / efficiency in agriculture (India, Indonesia, Tunisia)
- Change in cropping patterns (Cyprus, Spain; Guadiana, Mancha, Guadalquivir, Heihe)
- Agricultural policy reform (China, Heihe)
- Water policy reform (Indonesia, Heihe)
- Trade policy reform (almost all the studies)
- Development of policies to control food demand (Tunisia and indirectly China)
- Reinforcement of water management plans (Spain, China, Cyprus, UK, Netherlands, Germany; Okanagan).
- Close cooperation and aid strategies with producing nations (UK, Netherlands, Germany)
- Enlarge protected areas and increase control on water uses (Doñana)

Most responses are focused on agriculture and food demand. We can extract from the analysis that there is still large potential for the reduction of agricultural WFs and their impacts, especially by improving water productivities, changing cropping patterns and revising actual trade patterns. Nevertheless, more work is also needed in (i) integrated response formulation thinking, taking into account water, agriculture and trade policies, as well as social and economic factors, and (ii) the assessment of the sustainability of WFs, not only from the environmental perspective but also from the social and economic perspectives (see previous section) which will in turn contribute with the optimisation of the response formulation phase.

Table 1.6. List of responses formulated by the national case studies

Study	Response options
UK	Response options are proposed for UK businesses, government and consumers. From the government perspective: **In the UK:** increase household water metering with affordable pricing; ensure that water-efficient appliances are required in new and existing homes; develop water 'neutral' residential and business property; and reinforce and promote the Water Framework Directive and Habitats Directive. **Globally:** Incorporate sound water management as a key plank of UK aid strategy; measure the water needed to meet food security and the implications for UK policy support; facilitate dialogue and links between business and government with regard to impacts on water sources at production sites; support EU, World Bank and others to ensure that their aid portfolios are 'waterproofed'; and undertake sample water audits of government programmes to ensure that they do not have adverse unintended consequences on water, or promote misallocation of water resources.
Netherlands	Enhance bilateral cooperation between the Netherlands and the Dutch trade partners aimed at the reduction of the negative impacts of Dutch consumption on foreign water resources. Dutch government can also engage with businesses in order to stimulate them to review the sustainability of their supply chains.
Germany	Raise the financial means for the development of cooperation where improvements in the sustainable management of aquifers and river catchment areas are aspired, especially in water-scarce regions, where water mismanagement is practised. At the European level; demand for a consistent implementation of the EU Water Framework Directive for rivers and aquifers – especially in the Mediterranean countries of Spain, Italy and Greece, and Turkey. Agricultural subsidies of the EU should only be paid in the case of proven responsible utilisation of water.
China [1]	Formulate new and more appropriate agricultural policies, they are particularly important given China's continued significant investment in agricultural technology research in the past decades, the food self-sufficiency policy, and the increasing emphasis on reducing the development gap between rural and urban areas; which leads to agricultural policy reform.
China [2]	From a water resources point of view the water transfers discussed do not make sense. There must be other decisive factors to justify the strategy. Factors that could play a role are availability of suitable cropland, possibly labour availability or national food security.
India	From a water resources point of view, the current direction and magnitude of trade do not make sense. An increase in water productivity has a better chance of reducing the national water scarcity than the proposed water transfer. The river interlinking project mainly reduces local water scarcity, while water scarcity needs to be reduced significantly at a national level. The only long term option for reducing the national water scarcity and remaining food self sufficient is to increase the water productivity in India. The largest opportunity for this increase lies in East India, where there is water abundance and a large increase in water productivity seems possible.
Indonesia	Reform of Indonesian water policy, promotion of wise trade between provinces – i.e. trade from places with high to places with low water efficiency, improvement of water efficiency in those places that currently have relatively low efficiency, which equalises production efficiencies and thus reduces the need for imports and enhances the opportunities for exports.
Tunisia	The official policy aims at increasing the area under irrigation by 2030 by vastly improving water efficiency. A solution proposed could be to stabilise the irrigated surface at a level such that the increase in the efficiency of agricultural water use could compensate for the reduction of the agriculture water allocation. Other response options proposed are: improve the efficiency of water use in irrigation; include all water resources in the water balance, in particular those involved in rainfed agriculture production; improve intensive use of water and soil conservation techniques; diversify to plant varieties that are better adapted to aridity; develop suitable policies for management and control of food demand evolution; optimise agro-alimentary exchanges by considering their effects on the water resource balance (import of food requiring a lot of water and export of products requiring less water).

1 Liu and Savenije., 2008
2 Ma et al., 2006

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Study	Response options
Morocco	From an economic point of view it would be worth checking whether the exported commodities yield a relatively high income of foreign currency per unit of water used. From a water-resources point of view it would make sense to stimulate export of products with a relatively high foreign currency income per unit of water used and to import products that would otherwise require relatively a lot of domestic water per unit of dollar produced.
Spain	The Spanish Water Directorate General, approved a regulation that includes the analysis of the water footprint of the different socio-economic sectors as a technical criterion for the development of the River Basin Management Plans. Many regions in Spain have achieved the paradigm "more crops and jobs per drop" and they are heading now towards "more cash and nature per drop".
Cyprus	The current high water demanding crop pattern in Cyprus is driven by the subsidised irrigation policy of the government, which can explain the substantial amount of exported blue crop water use. Given the water availability and climatic conditions of the country, cropping patterns need to be modified towards rain-fed agriculture and concentrate on less water demanding crops like flowers, aromatic plants and winter crops which generally depend on rainwater. This will require strong political will and government intervention to convince the farmers towards such agricultural practises. In such a reallocation of water resources, policy makers will need to consider the opportunity cost of water in alternative uses.

Table 1.7. List of responses formulated by the river basin and regional case studies

Study	Response options
Guadiana & La Mancha, Spain	In addition to the demands of the Water Framework Directive, new policies in the Mancha region essentially point at either a change in cropping patterns or a drastic reduction of the irrigated surface. The results of the case studies support this paradigm shift by showing to what extent there is an imbalance between the region's water and land uses and its natural resources. However, it is also recognised that several obstacles challenge their implementation, some of which are found at the regional and the farm scales. Virtual water and water footprint assessment could inform production and trade decisions, promoting the production of goods most suited to local environmental conditions and the development and adoption of water efficient technology. Adopting this approach, however, requires a good understanding of the impacts of such policies on socio-cultural, economic and environmental conditions. Besides, water is not the only factor of production and other factors, such as energy, may come to play a role.
Guadalquivir, Spain	Improve water resource allocation searching for bigger economic, social and environmental productivity; increase water reuse (especially for the urban and industrial sectors); encourage less aggressive agricultural production (integrated or ecological agriculture); coordinate water policies with environmental, agricultural, energy and trade policies, taking into account the comparative advantage of the region in solar energy production, tourism, traditional crops (vineyards and olives) and vegetables.
Doñana, Spain	Supplementary measures to ensure the conservation of Doñana are needed, such as increasing conservation measures in the area surrounding Doñana sufficiently to ensure that the ecological character of Doñana is not damaged; enlarge the protected area to cover all the important zones around Doñana in order to protect the National Park from the threat represented by tourist development or ensuring better and stricter control of the extraction of water and the use of chemical products for agricultural purposes.

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Study	Response options
Heihe; China	Reducing the export of low value virtual water and maximizing high value virtual water is necessary in such an arid area. Producing the products with high water productivity such as cotton, grape and date, and reducing the water demanding products with less revenue are good options to improve efficiency of water consumption. With increasing water scarcity, the need for financial sustainability and declining financial resources available for irrigation and water resource development, reform of water pricing is essential in the region.
Okanagan, Canada	This information will provide a basis for the development of a water conservation strategy that is now being initiated by the Okanagan Basin Water Board. Decision makers can now assess in quantitative terms what activities are most water intensive and what the best trade-offs are in terms of water conservation.

1.3. Discussion

- What is the overall state of the art of the WF methodology as IWRM tool?

Since the presentation of the virtual water concept, a number of studies focused on virtual water trade issues have been published. The water footprint concept and water footprint assessment are more recent and only very few studies (presented in this report) have attempted to apply them at specific geographical units. All the studies analysed emphasise the utility of both virtual water flows and water footprint concepts as powerful informing tools in IWRM.

The mind-set of most of the case studies analysed is academic. They can be described as the pilot application of concepts developed by researchers. As the WF concept spreads and the methodology rapidly develops with strong scientific roots, policy-makers and water managers see the added value of this tool in the decision-making process. For example, Spain is the first country that has included the water footprint analysis into governmental policy making in the context of the EU Water Framework Directive. In September 2008, the Spanish Water Directorate General within the Ministry of the Environment and Rural and Marine Affairs approved a regulation including the WF analysis as a technical criterion for the development of the EU river basin management plans (Garrido et al., 2010). The Spanish case is an exception because (i) they are a water-scarce country, (ii) they have done WF scientific research, (iii) they have tested the methodology at the river-basin and national levels, and (iv) they have strengthened WF communications between researchers and water managers. Thanks to these conditions the Spanish have greatly contributed to the development and dissemination of the methodology. Cyprus has just started to follow a similar route.

The general framework proposed by the recently issued *Water Footprint Manual* (Hoekstra et al., 2009) provides the best available outline of the application of the water footprint methodology for different purposes. Nevertheless, generating more specific and practical guidelines for its application as a water demand management tool at geographical levels is an imperative step nowadays in order to facilitate the process of implementation of the methodology by water managers and policy makers around the world.

Finally, more research is needed in two main fronts: first, some specific technical aspects of the WF assessment need further investigation (described below). Second, the insertion of WF assessment results into a more down-to-earth and all-encompassing decision-making system, in which agricultural, water, trade and energy policies are considered simultaneously as well as economic, political and social factors.

- Which geographical units?

The definition of the geographical unit of work is related to the purpose of the study. In any case, the decision of applying the water footprint methodology for a given region is motivated by the necessity to better understand and quantify water and water related problems and possible solutions. Most of the case studies are at the national level, because data sources are more accessible at this level. On the other hand, the most effective decision-making process and policy formulation happens at the national level. If a country is big and/or has internal water scarcity problems, like in the case of China, India, Spain or Cyprus, it will tend to increase the resolution and to work at a provincial or river basin level internally. If a country has a high external water footprint and no "substantial" internal water scarcity problems, it will detail the study in the countries (and if possible river basins too) identified as hotspots. In any case, it seems that prioritisation of concrete actions happens at the river-basin level. For this purpose, a detailed water mass balance of water availabilities versus water footprints is required.

- What is new about the geographical application of the water footprint concept?

Water Demand Management (WDM) is a scarcity strategy that operates by lowering the water demand or reallocating limited water to higher value uses (Garrido et al., 2009). On one hand, the water footprint methodology is a comprehensive accounting tool for *all* possible consumptive uses of water (blue, green and grey). On the other hand, the methodology includes a water footprint sustainability assessment, which brings WDM one step forward in the reflection of the very nature and sustainability of such demands. It provides a comprehensive context to water managers in which the logic of water demands and reallocations are questioned from the viewpoints of equitability and sustainability. This is clearly shown by the figures obtained for the Okanagan (Canada), Doñana (Spain), Tunisia, Cyprus, India and China case studies.

- Which aspects need more work?

DATABASES IMPROVEMENT:

The success on the application of the water footprint methodology for a given geographical unit lays on the availability of data. This is effort-demanding especially for developing countries. Much data like agricultural or climatic information are available through global organisations like FAO. Nevertheless, when the spatial and temporal resolutions increase, data are insufficient, like the study for la Mancha region in Spain shows (Aldaya et al., 2008).

Databases on water availabilities and environmental flow requirements at the river basin level need also to be improved.

THE WATER FOOTPRINT OF PRODUCTION AND CONSUMPTION OF INDUSTRIAL GOODS:

The best available methods for the determination of the water footprint of the consumption of industrial goods at a national level are presented by Chapagain & Hoekstra (2004). They are based on a top-down approach, employing the industrial water withdrawal and the monetary value added by these goods. However, for the calculation of the water footprint of the consumption of industrial goods using a bottom-up approach, more information is needed on the virtual water content of individual industrial goods.

For the calculation of the industrial water footprint within a river basin level, not only industrial water consumption, but also industrial water pollution needs to be taken into consideration.

GREY WATER:

Very few case studies included the grey water component in the analysis, most probably because of lack of data. Hoekstra et al., (2009) state that if one is interested in water pollution and its relative importance on the available water resources, the grey water component should be included in the assessment. This should be the case not only for the industrial sector, but also for the agricultural and domestic sectors.

The methodology for the calculation of the grey WF needs more research. The grey WF is defined as the amount of water needed to assimilate the load of pollutants based on ambient water quality standards and natural ambient concentrations of pollutants (see Annex III, page 22). Datasets on ambient water quality standards and natural concentrations around the world are currently not available. The Water Footprint Network (WFN) has installed a grey water working group in order to provide research recommendations on this and other grey water research topics.

SUSTAINABILITY ASSESSMENT INDICATORS:

The case studies analysed apply selected sustainability assessment indicators depending on their objectives. The application of only one type of indicator (for example economic) may lead to oversimplified recommendations, as it mentioned for example in the Guadiana river basin study (Aldaya et al., 2008). Environmental, economic and social aspects should be regarded in an integrated way. There is a need of more detailed guidelines on how to evaluate the sustainability of a water footprint for a specific region encompassing these three aspects. The WFN has installed a Sustainability Assessment working group in order to provide practical recommendations on how to do a WF sustainability assessment as well as other sustainability assessment topics.

PRACTICAL GUIDANCE:

A consistent and practical guideline that facilitates the implementation of a WF assessment at a given geographical unit would enormously help the non-scientific community. The framework should recommend the inclusion of WF results into water, trade, energy and food demand policies.

Part 2: Policy framework and measures

2.1. Introduction

Part 1 of this report presents an overview of case studies showing how the Water footprint is currently applied or studied at different geographic levels. The case studies listed in Annex I also present potential applications for policy and practical measures to reduce water footprints or increase their sustainability. The applications vary from using the water footprint to:

- develop water conservation strategies (Okanagan)
- maximise economic and social benefits from water use and potential substitution of local water consumption with virtual water trade (Guadiana)
- compare different water uses in order to increase socio-economic efficiencies (La Mancha)
- underpinning the integrated planning and management of water considering environmental flow requirements (Doñana)
- change the way food security and water security concepts by showing the link with the global economy (Spain)
- inform agricultural policy on food water requirements in the future as a result of changing diets (China)
- assessing the economic rationale behind inter basin transfer schemes (India, China)
- bring water sustainability into the national sustainable consumption and production policies, drive economic sectors to reduction on water consumption, focus international cooperation policy on the basis of water footprint impacts (Netherlands, United Kingdom)
- understand the political ramifications water dependency for food security (Netherlands, United Kingdom)

From this list, it is clear that there are a variety of policy and practical measures to come to more sustainability water use, or in other words, to increase the sustainability of water footprints. However the listed applications are not complete, nor systematically structured to allow for a deeper understanding about how policies and measures can operate at different geographic scales. Also, the list mixes various policy sectors.

Looking more closely at the case studies and the role of water footprint in policy applications and practical measures, it can be concluded that the Water Footprint can perform two roles mainly: 1. to guide policy making and design of practical measures, by providing quantitative information that make problems more insightful and tangible and 2. to evaluate the result of policies and practical measures through understanding their effects on the sustainability of water footprints in quantitative ways. Water footprint in the policy environment serves thus as an indicator and not as an objective of the policies and measures in itself. The objectives of policies and measures are normally related to reducing water footprints and to increasing the sustainability of water footprints, in which sustainability can address environmental, social, economical and even political objectives. When the objectives of policies and measures are addressed in Part 2, it is these broad objectives that are referred to.

Part 2 of the report aims to structure the different policy and practical measures available to increase the sustainability of water footprints. It does to by first describing the policy environment. Then it describes the policy framework of the water, agriculture, environment, trade and energy policies. After this, the policy framework is connected with different geographical scales from global, national, river basin to the local levels to produce an overview of sectoral policies and measures at different geographical scales. Gaps in knowledge that currently exist are presented after the long list. And, Part 2 ends with conclusions that serve as an introduction to part 3.

2.2. Policy environment

In a context of unevenly distributed water resources and in some regions precipitation and drought conditions are increasing, enhanced water management is a major challenge for final consumers, businesses, water resource users, and particularly to water managers as well as policy makers in general.

From a global perspective, the total annual precipitation over continents amounts to about

110,000 km^3 whereas the global consumptive use is around 8,000 km^3 (Falkenmark and Rockström, 2004; Comprehensive Assessment of Water Management in Agriculture, 2007; Hoekstra and Chapagain, 2008; WWAP, 2009). Concerning the environmental water requirements, Falkenmark and Rockström (2004) provided a first estimate that adds up to 93% of total water resource use, 38% blue and 62% green (including runoff, grazing, grasslands, forests and woodlands, arid lands, wetlands, lake evaporation and others). While human direct use of water represents about 7% (including blue and green food, domestic and industry uses). Even if considered the main water user, hitherto, environmental water requirements have rarely been taken into account in water resources management. Obviously, from the global point of view it is of the greatest relevance to analyse this concept and provide more accurate estimates. In relation to human water consumption, urban water supply represents about 4.6% of total water consumption, whereas the industrial sector amounts to 9.6% and the agricultural sector to 85.8% (Hoekstra and Chapagain, 2008). In the agricultural sector about two thirds of the total volume of water consumed in crop production worldwide is green water (Chapagain and Hoekstra, 2004; Fraiture et al., 2004; Rockström et al., 1999). 16% of the global water consumed is not meant for domestic consumption but for export (Hoekstra and Chapagain, 2008). The water challenge is therefore closely tied to food provision and trade.

However, more accurate figures are needed in relation to the water quantity that is accessible, reliable and environmentally sustainable for human use, which is in principle a smaller quantity than the absolute raw water available in nature. Furthermore, the global optimal water allocation should be taken into account in order to make local or regional water management and allocation decisions (Hoekstra et al., 2009). In relation to this, more specific numbers are also needed. It is worth mentioning that the uneven distribution of water in space and time is a problem. Shortages of fresh water and the increasing pollution of water bodies are becoming limiting factors in the economic and social development of many countries throughout the world (Gleick, 1993). In any case, the world has enough freshwater to produce food for all its people over the next half century. But world leaders must take action now – before the opportunities to do so are lost (Comprehensive Assessment of Water Management in Agriculture, 2007; Rogers, 2008).

Under these conditions, obtaining clear data on environmental water requirements, water footprint and virtual water trade would allow to attain a transparent multidisciplinary framework for informing decision making. It is critically important that a certain volume of water is planned for the maintenance of ecosystem functions and the services they provide to humans. Planning water allocation taking into account the environmental water needs would be helpful to achieve the right balance between allocating water for direct human use (e.g. agriculture, power generation, domestic purposes and industry) and indirect human use (maintenance of ecosystem goods and services) (Acreman 1998). This is the only way to achieve a win-win solution for satisfying the human needs without degrading the environment. In this context, moving towards sustainable land use planning; giving priority to water savings and water efficiency measures over any other alternatives, especially in water-scarce areas; assessing the environmental impact of such alternatives as a last resort and further integrating water issues into all sectoral policies are also essential (EC, 2007). Adaptation to climate change will add a new challenge to the existing issues.

Big changes are needed in water management policy to achieve and ensure food security and protection of ecosystems. There is however no blueprint for managing water resources: different strategies are required for different situations. Water related problems are very different in developed and developing countries. For instance, many developing countries require investments in infrastructure, considering the range of options available. Where infrastructure is already heavily developed, a focus on improving productivity, reallocating supplies, and rehabilitating ecosystems is required. In all cases, supporting institutions, adapted to changing needs, are essential (Comprehensive Assessment of Water Management in Agriculture, 2007).

Against the above background, and in order to contribute to a better management of water resources, this report presents a set of policy options at international, national, river basin and local levels to address and mitigate the challenge posed by water scarcity and drought worldwide. This section has been divided in two. In the first part water-related policies are reviewed. In the second one a comprehensive set of measures is provided highlighting the current gaps in knowledge.

2.3. Policy framework

2.3.1. Water policy

The traditional water policy approach has always been supply and producer oriented. The water footprint concept has been introduced to have a demand and consumer oriented indicator as well (Hoekstra, 2003; WFN, 2010). This approach shifts the previous emphasis on supply towards demand management, where demand management is not limited to promoting water use efficiency at field level but extended to wise water governance in supply chains as a whole, thus also addressing trade and consumption patterns. This asks for a rethinking of the existing model of water use with adaptations implying social, political and cultural changes that result in a significant reduction in water demand.

Furthermore, it is becoming increasingly important to put freshwater issues in a global context (ibid.). Local water depletion and pollution are often closely tied to the structure of the global economy. With increasing trade between nations and continents, water is more frequently used to produce exported goods. International trade in commodities implies long-distance transfers of water in virtual form, where virtual water is understood as the volume of water that has been used to produce a commodity and that is thus virtually embedded in it (Allan, 1993, 1994, 1998a,b, 1999a,b, 2002). Knowledge about the virtual-water flows entering and leaving a country can cast a completely new light on the actual water scarcity of a country. Along these lines, virtual water flow analysis in relation to agricultural commodity trade is very useful to investigate the extent to which a revision of trade agreements at regional and global level can improve the water balance.

NATIONAL WATER STATISTICS, NATIONAL WATER PLAN AND RIVER BASIN PLANS

Traditionally countries formulate national water plans by looking how to satisfy water users. Even though countries nowadays consider options to reduce water demand in addition to options to increase supply, they generally do not include the global dimension of water management (Hoekstra et al., 2009). In this way they do not explicitly consider options to save water through import of water-intensive products. In addition, by looking only at water use in the own country, most governments have a blind spot to the issue of sustainability of national consumption. As a matter of fact many countries have significantly externalized their water footprint without looking whether the imported products are related to water depletion or pollution in the producing countries. Governments can and should engage with consumers and businesses to work towards sustainable consumer products. Making national water footprint accounting a standard component in national water statistics would provide a stronger information basis to formulate a national water plan and river basin plans that are coherent with national policies with respect to the environment, agriculture, energy, trade, foreign affairs and development cooperation.

Traditional national water use accounts only refer to the water withdrawal within a country. They do not distinguish between water use for making products for domestic consumption and water use for producing export products. They also exclude data on water use outside the country to support national consumption. In order to support a broader sort of analysis and better inform decision making, the national water use accounts need to be extended (Hoekstra et al., 2009).

As an indicator of 'water use', the water footprint differs from the classical measure of 'water withdrawal' in three respects:

- it is not restricted to blue (surface and ground) water use, but also includes green and grey water.
- it is not restricted to direct water use, but also includes indirect water use.
- it does not include blue water use insofar this water is returned to where it came from.

Water footprint accounts give spatio-temporally explicit information on how water is appropriated for various human purposes. They can feed the discussion about sustainable and equitable water use and allocation and also form a good basis for a local assessment of environmental, social and economic impacts. A better knowledge of the water footprint and virtual water 'trade', particularly in arid and semiarid countries, can be very useful for developing a comprehensive instrumental framework across time and space to support water management decisions. Ultimately, this knowledge-based tool can be used by the water authorities to achieve a more efficient allocation of water resources. In this context, Spain was the first country in the EU to adopt the water footprint evaluation in governmental policy making.

In September 2008, the Spanish Water Directorate General, under the competence of the Ministry of the Environment and Rural and Marine Affairs, approved a regulation that includes the analysis of the water footprint of the different socio-economic sectors as a technical criterion for the development of the River Basin Management Plans, that all EU Member States will have to accomplish by 2009 (and every six years thereafter) as part of the requirements of the Water Framework Directive (Official State Gazette, 2008) (Aldaya et al., 2009).

BEYOND GDP: ASSESSING SOCIAL, ECONOMIC AND ENVIRONMENTAL PROGRESS

Economic indicators such as GDP were never designed to be comprehensive measures of well-being. Complementary indicators are needed that are as clear and appealing as GDP but more inclusive of other dimensions of progress – in particular environmental and social aspects. We need adequate indicators to address global challenges such as resource depletion and climate change. As explained in the first section, the water footprint is a freshwater sustainability indicator that looks at both direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business. Water use is measured in terms of water volumes consumed (evaporated) and/or polluted per unit of time. In this sense analysing the water footprint of a nation and its relation to economic growth across time can provide new insights on the real sustainability of a country, since it not only includes the water consumption and pollution within the country but also the water consumption and pollution outside the borders of the country. Pollution reduction and water savings in developed countries could be a result of increased pollution and consumption of water-intensive products imported from developing countries. Countries may reduce their internal water footprint by increasing the external water footprint in exporting countries. Since, in mature water economies, domestic water resources are generally limited, it is instructive to see whether a country's external water footprint grows along with its economy (Garrido et al., 2010). If this is the case, then its economy could still be coupled to water resources, though abstracted and integrated in the exporter's production processes. On the other hand, economic growth could be decoupled from all primary variables related to water use, including virtual water trade and water footprint.

WATER PRICING

The Dublin Principle No. 4 (adopted at the International Conference on Water and Environment, Dublin 1992) states that "water has an economic value in all its competing uses and should be recognized as an economic good". One of the most important conditions for efficient water use is water pricing (Hoekstra et al., 2009). Users generally pay a price for freshwater that is far below its real economic value. Most governments subsidise water supply on a huge scale by investing in infrastructure like dams, canals, water purification, distribution systems and waste water treatment. These costs are often not charged to the water users. As a result, there is insufficient economic incentive for water users to save water. Besides, water scarcity is generally not translated into an additional component in the price of goods and services that are produced with the water, as happens naturally in the case of private goods. Finally, water users generally do not pay for the negative impacts that they cause on downstream people or ecosystems (ibid.). Water inputs therefore do not form a substantial component of the total price of even the most water-intensive products. Consequently, the production of goods – even though various sorts of goods require a lot of scarce water inputs – is not or hardly governed by water scarcity.

In this context, introducing the 'user pays' principle would put an end to needless losses or waste, ensuring that water remains available for essential uses, including all parts of transboundary river basins. In other words, it would encourage efficient water use (EC, 2007). This could be achieved putting in place water tariffs based on a consistent economic assessment of water uses and water value, with adequate incentives to use water resources efficiently and an adequate contribution of the different water uses to the recovery of the costs of water services. The 'user pays' principle needs to become the rule, regardless of where the water comes from. Nevertheless, private households should, irrespective of their available financial resources, have access to adequate water provision.

It would be also needed to enhance efforts to introduce compulsory metering programmes in all water using sectors and implement systematic control over water abstraction.

ALLOCATING WATER MORE EFFICIENTLY: IMPROVING LAND-USE PLANNING

Land-use planning is one of the main drivers of water use (EC, 2007). The Dublin principle No. 1 recommended that water problems be considered in relation to land-use planning, socio-economic development, and the protection of other natural resources. This is well-captured by the definition of Integrated Water Resources Management (IWRM) by the Global Water Partnership (GWP, 2000): 'A process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems'. Inadequate water allocation between economic sectors results in imbalances between water needs and existing water resources. A pragmatic shift is required in order to change policy-making patterns and to move forward effective land-use planning at the appropriate levels.

In this sense effective management links land and water uses across the whole of a catchment area or groundwater aquifer. The economic development of some river basins can lead to adverse effects on water resource availability. A large-scale agricultural, industrial and urban development affects the infiltration of water at local level, increased the runoff of rainwater, reduced groundwater recharge and the availability of water for vegetation and increased evaporation. Agriculture, in particular, can have significant impacts notably related to irrigation and pollution. Agricultural and rural development policies aimed at lowering the impacts of agricultural activities on water resources thus play a central role on this issue (see section 3.3). It is also important to further assess the inter-linkages between biofuel development and water availability. Providing a strong incentive for the development of biofuels based on waste, residues and other non-agricultural feedstock could contribute to reduce pressure on the water needs in the agricultural sector. To a lower extent, in urban or industrial areas, the mass use of cement and asphalt predominate which results in rainwater often carried away through public sewage networks, instead of saturating the soil and ecosystems. The widespread development of tourist resorts in water scarce river basins can also lead to impacts on local water resources like in the case of the Doñana National Park in the Guadalquivir river basin in the south of Spain (Sousa et al., 2009).

As already mentioned in section 1, the first step is to identify the river basins that are facing quasi-permanent or permanent water scarcity, which could be optimally defined as the total water footprint to water availability for human use. The water available for human use refers to the total water availability minus the environmental water requirements. Water quantity and quality issues will be efficiently addressed only if the functioning of the water cycle is fully considered; analysing both the environmental water requirements and the water footprint considering the green, blue (surface and ground) and grey water components. All production including irrigated and biomass production and all economic activities should be adapted to the amount of green and blue water available locally taking also into account the virtual water trade option. This is a key condition for sustainable land-use planning and particularly important for the implementation of the river basin management plans. Depending on the context, different steps could be taken to reduce the pressure on water resources, such as a ban on increases in water abstraction in overexploited areas, assessment of the volumes that can be sustainably abstracted, a review of the abstraction authorisations, and an obligation to put in place collective irrigation organisations in charge of limiting and distributing abstraction volumes among water users. Improvement of water infiltration into the soil and progress towards soil saturation will help restore groundwater and surface water resources. It is crucial to maintain and increase organic matter in the soil as this can absorb up to twenty times its weight in water (EC, 2007).

There is currently little evidence that land use challenges are being fully integrated into the water management decisions. Further steps need to be taken on this issue at all levels.

DROUGHT MANAGEMENT

Following the increasing droughts in the past few years, and in order to efficiently prevent and mitigate drought impacts on environment, society and economy, governments could develop drought management plans in relevant river basins (EC, 2007). Some nations are implementing additional measures, such as water company drought plans or national drought plans. Other measures are planned, such as the setting up of a system for the prediction and management of droughts. The associated measures often result in comprehensive drought risk management plans with water stress area mapping, alert levels, warning systems, etc. In any case, agriculture being the largest water consumer, it is of utmost importance to understand how green and blue water components vary with time and from place to place. This variation has direct implications not only for water productivity and allocation but also for drought management, which in turn are linked to international trade.

The development of an International Drought Observatory could enhance the knowledge of the issue (e.g. European Drought Observatory) (EC, 2007). This would serve as a platform for forecasting, detection and monitoring and for exchange of information. It could adopt a multi-scale approach, which is in line with the subsidiarity principle and would provide consistent information. Efficient alert systems are also an essential dimension of risk management. An early warning system would therefore follow suit to improve the drought preparedness of the relevant authorities. This system would integrate relevant data and research results (e.g. spatio-temporally specific green, blue and grey water footprint estimates), drought monitoring, detection and forecasting on different spatial scales, from local and regional activities to international overview, and would make it possible to evaluate future events.

FINANCING WATER EFFICIENCY

According to the European Commission Communication on Water Scarcity and Droughts (EC, 2007), water saving must become the priority and all possibilities to improve water efficiency must therefore be explored. Policy making should be based on a clear water hierarchy. Additional water supply infrastructures should only be considered as an option when other options have been exhausted, including effective water pricing policy and cost-effective alternatives. Water uses should also be prioritised: it is clear that public water supply should always be the overriding priority to ensure access to adequate water provision.

In many cases, even though they are cost-effective, a number of measures are not taken as they are unaffordable. National priorities can also be counterproductive in promoting additional water supply infrastructure as the primary option, going against the logic of the water hierarchy and the need to support water-saving and efficiency measures in the first place. It continues to be essential to ensure that the allocation of funding is sufficiently conditional on independent and ex-ante evidence of full utilisation of water savings and efficiency, effective water pricing policy and metering, minimum performance of public water supply networks or recovery of the costs of projects by the water users concerned.

Several measures to tackle this issue, such as investment in infrastructure related to water management, clean and water-efficient technologies, are provided in Table 1.

Alternative options like desalination or waste water re-use are increasingly considered as potential solutions across the world. Desalination of salt or brackish water can be a partial solution for freshwater scarcity. On the one hand, desalination could be one of the promising options for drinking water for ever-increasing demands in densely populated coastal areas. Furthermore, coastal areas downstream of the basin are generally in a weaker hydro-geographical position. Seawater desalination thus provides an attractive alternative from geopolitical and security perspectives. On the other hand, however, desalination is an energy-intensive process and produces highly concentrated salt brines as a by-product.

FOSTERING WATER EFFICIENT TECHNOLOGIES AND PRACTICES

All economic sectors need to continue to develop water-efficient technologies and practices, with a particular focus on those sectors where huge water quantities are consumed (e.g. agriculture). In many cases there is still room for improving water performance. For instance, in some European regions, leakages in irrigation networks can exceed 50%. Similar wastage of water has been recorded in public water supply networks in some cities. Finally up to 30% of the volume of water consumed in buildings could be saved (EC, 2007). In addition to improving technologies, the upgrading of water management practices is a necessary instrument in all sectors where huge quantities of water are used (mainly agriculture). This requires substantial changes on the way in which water is distributed and used.

A list of measures is presented in Table 1 including developing legislation for water using devices and voluntary agreements.

For instance, ecodesign legislation could be implemented in order to increase water efficiency in product groups, including water using equipments, in particular irrigation equipment. Also, washing machines and dishwashers could be covered.

Minimum water requirements in building regulation or national building standards could also be introduced. Other possibilities include specific water management requirements for future 'high environmental quality' buildings, the review of national regulations to ensure the water efficiency of buildings and establish a comprehensive water performance standard for buildings or the introduction of minimum compulsory water efficiency standards for any new publicly funded housing (EC, 2007).

The steps taken to reduce leakages in water networks include systematic and regular external audits of leakage levels, the introduction of incentives to encourage water companies to bring leakages in water networks below a given level, the introduction of preconditions of minimum performance in existing networks for the delivery of public funds for new water supply networks, publication of the performance of networks in each municipality on the internet, the introduction of water company targets with possible fines in case of failure. Excessive leakages remain an issue despite the above references and much more can be done (EC, 2007). National governments have a particular responsibility for improving leakage detection and upgrading networks.

As regards the development of voluntary agreements with all economic sectors that need water, initiatives are expected to be taken at international level. For example, the Action Plan on SCP/SIP to establish a Retailer Forum in order to encourage inter alia sustainable water consumption for major European retailers and their supply chains (EC, 2007). A few Member States have developed agreements with specific economic sectors, such as golf courses, the building sector, and the food and drink sector. In some Member States, agreements involving local authorities, NGOs and water agencies have been adopted at local and regional levels in order to promote and increase water savings. In general, voluntary agreements remain limited and need to be further extended, as they are able to deliver significant benefits.

DEVELOPMENT OF A WATER-SAVING CULTURE

To develop a water-saving and efficiency culture, the role of civil society is crucial. Developing a responsible water-saving and efficiency culture requires an active awareness-raising policy in which all actors in the water and water-related sectors (e.g. agriculture, trade) need to be involved (EC, 2007). Information, education and training are priority areas for action.

It is increasingly recognized that the water footprint is a very useful concept as an awareness raising tool and educational device (Hoekstra et al., 2009; The Economist, 2008). Consumers increasingly demand more information on the way water is used at all stages of the industrial or agri-food process. Labeling could be a way to provide targeted information to the public on water performance and on sustainable water management practices. The marketing of ever more efficient devices or "water-friendly" products could be encouraged (Alliance for Water Stewardship, 2010).

In line with Corporate Social Responsibility (CSR), economic operators involved in quality or certification schemes should be encouraged to promote their products on the basis of the demonstrated efficient use of water.

- Encourage the inclusion of rules on water management in existing and future quality and certification schemes (ISO Water Footprint Initiative).
- Explore the possibility of expanding existing labeling schemes whenever appropriate in order to promote water efficient devices and water-friendly products.
- Further encourage the development of educational programmes, advisory services, exchanges of best practices and large targeted campaigns of communication focused on water quantity issues.
- Different measures could be developed such as actions for communication and education in order to increase public awareness on water quantity issues:

information campaigns at national, regional or local level; school competitions on water efficiency; free advice to the business sector; a website; inclusion of water issues in educational programmes and development of actions at school to promote water saving devices; development of a national strategy to educate consumers on efficient water use; exchange of good practices on irrigation.

IMPROVEMENT OF KNOWLEDGE

Finally, in order to be fully effective, policy action on water scarcity and droughts needs to be based on high-quality knowledge and information on the extent of the challenge and projected trends (EC, 2007). Existing international and national assessment and monitoring programmes are neither integrated nor complete. Filling knowledge gaps and ensuring data comparability is therefore a precondition. In this context, research has a significant role to play providing knowledge and support to policy making.

Support, coordination and dissemination of research efforts between the national levels will ensure the best match between research needs and what is on offer to society including practitioners and policy makers. Financial instruments for the environment and transboundary programmes on water scarcity and drought management should be coordinated. Synergies have to be sought between policy and research in this respect.
The use and exploitation of the results of research on water resources could be disseminated and facilitated through internet resources. The Water Footprint Network website (WFN), for instance, provides a platform to integrate and disseminate such information. Research and technological activities in this area, including networking, should be explored, enhanced and encouraged.

Finally, public participation is essential in river basin planning as emphasized in water related legislation (e.g. Water Framework Directive, 2000; Canada Water Act, 2010).

INTEGRATED MANAGEMENT OF WATER RESOURCES

Further integration of water-related concerns into water-related sectoral policies is paramount in order to move towards better water governance. Integration achievements at international, national, river basin and local levels vary widely from one sector to another. In general terms, there is a lack of consistency and, in some cases, even counter-productive effects on water resource protection.

2.3.2. Agricultural policy

Most authors admit the absolute relevance of agriculture not only for food security but also for water security. About 86% of all (blue and green) water consumed by humans (domestic, industry, energy, and others) is used for rain-fed or irrigated agriculture (Hoekstra and Chapagain, 2008). The volume of water consumed for agriculture seems to be in the order of 7000 km^3/year (Comprehensive Assessment of Water Management in Agriculture, 2007). Water policy in relation to farming is thus a globally significant issue.

First of all it is very important to change the way we think about water and agriculture (Comprehensive Assessment of Water Management in Agriculture, 2007). Thinking differently about water is essential for achieving the triple goal of ensuring food security, reducing poverty, and conserving ecosystems. Instead of a narrow focus on rivers and groundwater, view rain as the ultimate source of water that can be managed. Instead of blueprint designs, craft institutions while recognizing the politically contentious nature of the reform process. And instead of isolating agriculture as a production system, view it as an integrated multiple-use system together with urban and industrial uses and as an agro-ecosystem, providing services and interacting with other ecosystems.

Gaining more yield and value from less water can reduce future demand for water, limiting environmental degradation and easing competition for water (Comprehensive Assessment of Water Management in Agriculture, 2007). A 35% increase in water productivity could reduce additional crop water consumption from 80% to 20%. More food can be produced per unit of water in all types of farming systems, with livestock systems deserving attention. But this optimism should be met with caution because in areas of high productivity only small gains are possible. Larger potential exists in getting more value per unit of water, especially through integrated systems and higher value production systems and through reductions in social and environmental costs. With careful targeting, many developing countries can benefit from water productivity gains in crop, fishery, livestock, and mixed systems.

A good number of authors consider that rain-fed agriculture should play a more important role in providing the food for the increasing world population (Falkenmark and Rockström, 2004; Comprehensive Assessment of Water Management in Agriculture, 2007; Rockström et al., 2007). Rainfed agriculture can be upgraded by improving soil moisture conservation and, where feasible, providing supplemental irrigation (Comprehensive Assessment of Water Management in Agriculture, 2007). These techniques hold underexploited potential for quickly lifting the greatest number of people out of poverty and for increasing water productivity, especially in Sub-Saharan Africa and parts of Asia (ibid.). Mixed crop and livestock systems hold good potential, with the increased demand for livestock products and the scope for improving the productivity of these systems. Nevertheless, during droughts, nations that rely on green-water based crops seem to be at greater risk of food shortages than other nations. Due to climate variability rainfall-based crop production is less reliable than surface or groundwater based production. However, since global commodity markets are well integrated, imports from other countries have the potential to replace green water-dependent crops during dry periods and reduce the risk of famine in importing countries (Aldaya et al., 2009). A complicating factor with respect to rural economies and the use of water, mainly green water, are the trade barriers and heavily subsidised USA, EU and Japanese agricultural sectors. This support adversely affects the rural economies of other countries, especially poor countries vulnerable to fluctuations in world market prices (Allan, 2001). Farmers in these countries cannot compete with subsidised commodities that depress local prices and reduce domestic production (Rosegrant et al., 2002). Furthermore, since international commodity prices depend on the market, droughts will boost prices so that some poor urban populations will be able to buy less food or switch to relatively cheaper foods.

The era of rapid expansion of irrigated agriculture is over (Comprehensive Assessment of Water Management in Agriculture, 2007). A major new task is adapting yesterday's irrigation systems to tomorrow's needs. Modernization, a mix of technological and managerial upgrading to improve responsiveness to stakeholder needs, will enable more productive and sustainable irrigation. As part of the package irrigation needs to be better integrated with agricultural production systems to support higher value agriculture and to integrate livestock, fisheries, and forest management.

Water related subsidies may harm the environment since they can lead to the overuse of water, cultivation of water-inefficient crops and use of inefficient technologies. For instance, incentives for growing water-inefficient crops in inappropriate regions may result in pollution and depletion of water bodies. The water footprint analysis, differentiating between the green and blue water components, could prove as a very useful tool in identifying the crops suitable to the climatic conditions and achieving optimal cropping pattern planning. By also evaluating the water footprint in terms of m^3/€— bringing the pioneering approach of the water footprint based on m^3/Tn to a socio-economic context — the productive economy is better integrated in the analysis (Garrido et al., 2010). This provides a distinctive view of WF and allows for a closer linkage between water productivity and water scarcity, in physical and economic terms. Traditionally, in the EU, cropping patterns have been profoundly influenced by farm and trade policies (Varela-Ortega, 2008), but now, due to more decoupled modes of farm income support, EU farmers are responding more to market signals. And most of these originate from global markets, offering broad opportunities to exploit the connections between food markets and farm trade and water policies.

A major limitation related to agriculture and water quality has been the lack of well-established relationships between agricultural practices and water quality. Non-point source pollution is a dynamic and site specific process. Emissions from non-point sources are either impossible to observe or their observation is prohibitively expensive. Water pollution by nitrates is by far one of the main environmental problems associated with agricultural activities. Furthermore, nitrates are highly soluble and migrate easily into groundwater through the soil, making it difficult to establish a link between nitrogen supply and water pollution. In this sense, the grey water footprint analysis based on ambient water quality standards (e.g. EPA, 2007) could play an important role for providing transparent information for improved decision making.

2.3.3. Environmental policy

The environmental green and blue water requirements add up to 93% of total water resource use according to first estimates by Falkenmark and Rockström (2004). This is therefore a very important issue from a global perspective. Even if considered the main water user, hitherto, environmental water requirements have rarely been taken into account in water resource assessment and management.

Environmental water requirements or environmental flow requirements refer the quantity, quality and timing of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems (King et al., 2000; IUCN 2003). These requirements are defined by both the long-term availability of water and its variability and are established through environmental, social, and economic assessment (ibid.). Obtaining clear data on environmental water requirements and comparing them with the water footprint assessment would allow attaining a transparent multidisciplinary framework for informing water allocation decisions. It is critically important that a certain volume of water is planned for the maintenance of ecosystem functions and the services they provide to humans. Planning water allocation taking into account the environmental water needs would be helpful to achieve the right balance between allocating water for direct human use (e.g. agriculture, power generation, domestic purposes and industry) and indirect human use (maintenance of ecosystem goods and services) (Acreman 1998). This is the only way to achieve a win-win solution for satisfying the human needs without degrading the environment.

Even if some countries are moving ahead in relation to environmental water requirements (South African Water Act, 1998; Australian Water Act, 2007), further research is needed on this topic. For example, groundwater allocation processes have traditionally not considered environmental values. The long-term viability of groundwater dependent ecosystems requires that they be recognised, their water requirements understood and this understanding be built into groundwater allocation processes. This knowledge should also be incorporated in the ecological flow proposals which must find the ultimate conformity and consistency among the legal set. Another question that should also be incorporated into water allocation decisions and environmental water requirements is the green water used by natural vegetation. Hitherto, the environmental water requirement studies have mainly focused on blue water use without considering the green water evapotranspirated by the natural vegetation (e.g. Smakhtin et al., 2004).

2.3.4. Trade policy

Traditionally, water resources management has been dealt with from the local, river basin or national perspective. Even if it is increasingly recognized that water governance has a global dimension, the linkages between international trade and freshwater scarcity are rarely analysed.
An obvious effect of international trade in water-intensive commodities is that it generates water savings in the countries that import those commodities. This effect has been discussed since the mid-1990s (Allan, 2001; Hoekstra, 2003). The other side of international trade in water-intensive commodities is that it takes water in the exporting countries, which can no longer be used for other (domestic) purposes. Besides, the social and environmental costs that are often associated with water use remain in the exporting countries; they are not included in the price paid for the products by the consumers in the importing countries. International trade can save water globally when a water-intensive commodity is traded from an area where it is produced with high water productivity (low water input per unit of output) to an area with lower water productivity (high water input per unit of output). On the other hand, of course, there can be a 'global water loss' if a water-intensive commodity is traded from an area with low to an area with high water productivity (Hoekstra and Chapagain, 2008).

Even though nowadays water is seldom the dominant factor determining trade in water-intensive commodities, it can become increasingly important in a context of greater scarcity and demand. On the other hand, currently, virtual water flows are mainly subordinated to world trade rules. World Trade Organization (WTO) policies affect agricultural policies, and these in turn affect irrigation water use. The WTO rules apply to most products but still exclude or include to a limited extent services and agricultural products. Because 85% of the water consumption in the world occurs in agriculture, concerns with respect to sustainable freshwater use can still be taken into account in the negotiations in the Doha Development Round, the current trade-negotiation round of the

World Trade Organization which started in 2001. Trade in agricultural products is one of the key focus areas of the current negotiations. From a sustainable-water-use perspective it is key that any new rules on international trade in agricultural products should include provisions that ensure that efforts to contribute to more sustainable water use behind the products traded are promoted and rewarded (Hoekstra, 2010).

Currently there is an imbalance between international trade agreements and international agreements on sustainable water use, because the former are strong and the latter weak. Most relevant is that internationally binding agreements on sustainable water use do actually not exist. There are no international agreements of the type that have the strength to restrict trade in cases where it negatively affects local water systems. It is argued that fair international trade rules should include a provision that enables consumers, through their government, to raise trade barriers against products that are kept responsible for harmful effects on water systems and indirectly on the ecosystems or communities that depend on those water systems. Hoekstra (2010) identifies several mechanisms to better ensure that trade and sustainable water use goes hand in hand: product transparency, e.g. through a water label, an International Water Pricing Protocol and an International Water-Footprint Permit System.

2.3.5. Energy policy

This is a topic receiving increasing attention in most countries in its double aspect: water for energy; and energy for water.

It is generally accepted that emissions of greenhouse gasses, such as CO_2 from fossil energy carriers, are responsible for anthropogenic impacts on the climate system. In this context, there has been a remarkable shift in policy attitudes towards CO_2-neutral energy carriers such as biomass. The production of biomass for food and fibre in agriculture requires about 86% of the worldwide freshwater use. In many parts of the world, the use of water for agriculture competes with other uses such as urban supply and industrial activities. In a scenario of increasing degradation and decline of water resources, a shift from fossil energy towards energy from biomass puts additional pressure on freshwater resources (Gerbens-Leenes et al., 2008; 2009). Therefore, biofuels based on waste, residues and non-agricultural feedstock should be promoted. Hydropower seems to be the second most water-intensive energy sector (ibid.). However, it seems that the use of water for cooling electric thermo-power plants has a greater economic productivity in comparison with other uses of water to produce energy. Currently with the emphasis in the thermosolar energy in many arid and semiarid countries this topic deserves a thorough analysis. For instance, a preliminary analysis for a thermosolar plant in South Spain seems to show that the economic productivity of the water used for the plant is about 200 times higher than the economic productivity of that water used to produce cotton (Llamas, oral communication). This is going probably to require a change in the Water Code of several countries. In any case, the analysis of the implications of energy scenarios for water demand would provide interesting information for policy-makers both at a national and at a global level.

The energy for water uses seems to be very different from region to region. For instance, in California about one third of the electric energy consumption is used in water activities (including the domestic heating). In Spain this proportion seems to be significantly smaller. In any case a more detailed analysis seems appropriate.

Finally, water and energy policies should be harmonized so that energy policies do not increase the water footprint of the energy sector and that water policies do not increase the energy use and carbon footprint of the water sector.

2.4. Water footprint reduction measures

Water resource management clearly impacts on many other policy areas (e.g. energy, food security, nature conservation). Thus, the appraisal of water footprint management and impact reduction options needs to be conducted across multiple water-dependent sectors and scales. This information has been summarized in Table 1, which identifies water footprint management and impact reduction policy measures in each box. Besides, gaps in the policy framework and suggestions for further work are pointed out.

Table 1 Water footprint management and impact reduction policy measures in a multidisciplinary multi-scale framework

SCALE **Policy sector**	**Global / International**	**Role of water footprint**
Agriculture	Minimizing the water footprint while ensuring food security through international cooperation and agreements on: • Environmentally sound technology transfer and know-how. • Improving global grain stock policies, which buffer dry periods. • Abolition of aid for energy crops for the production of biofuels and electric and thermal energy produced from biomass. • Promoting capacity building, which might be instrumental to reduce the water footprint. • In public and/or private investment policies, include water footprint and water scarcity knowledge to provide a framework for prioritizing investment. Include water footprint standard and benchmarks as a precondition for investment.	• Compare the WFs of different technologies. • WF could indicate the sustainability of the grain cultivation. • WF can point to competition for water between food and energy crops. • WF can be used to create awareness on water consumption related to behaviour. • Apart from poverty or other indicators, WF can inform e.g. national development aid policy in relation to where country external WF has most water related impact.
Environment	• Cooperation, informed decision-making and development of transboundary arrangements on a regional level between countries with shared natural resources based on water footprint knowledge and sustainable yields. • Invest and strengthen the institutions responsible for providing and managing water resources for people, industries, energy and eco-systems. • International cooperation on an international protocol on water pricing.	• WF can provide additional information; WF of regional trade (agriculture, energy) in relation to transboundary water management and allocation. • Water footprint knowledge should be included in this, no other specific role. • WF shows how countries externalise their water demands and associated environmental and social costs, can be translated in pricing for WF reduction, WDM or even offsetting.
Foreign and development cooperation	• Promote an international agreement on world-wide water footprint reduction. • Promote an international agreement on product transparency.	• WF provides the indicator for WF reduction. • WF can inform a product transparency scheme as indicator.
Industry	International cooperation on: • Water-certification of industries and retailers. • A water-label for water-intensive products. • Shared guidelines on water-neutrality for businesses • Development of standards for environmental management systems, such as ISO and EMAS standards. • Information exchange system on new technologies at national as well as regional and international levels (Bates et al. 2008).	• WF can be one of the indicators to test certification criteria. • WF can be one of the indicators to test labeling criteria • is about WF itself • WF compares on of new technologies.
Trade	• Accounting for water in the rules of international trade (WTO, EU) as a mechanism to improve global water efficiency based on water productivities and comparative advantage in water.	• WF is the indicator to be inserted alongside other trade data, work has started with ITC.

SCALE **Policy sector**	**National**	**Role of water footprint**
Water	• Adopt the national water footprint accounting scheme to broaden the knowledge base for making well-informed decisions. • Use information on water footprints and virtual water trade to support the formulation of national water plans. • Use the water footprint and its relation to economic growth as a water sustainability indicator beyond GDP. • For national water saving: decrease the virtual water export, increase the virtual water import of water-intensive but sustainable commodities and reduce the water footprint within the nation. • For reducing national water dependency: reduce the external water footprint. • Allocate the available domestic water resources such that the country produces goods for which it has a comparative advantage relative to other countries, understand the economic water productivity of different goods and services. • Introduce water pricing policies to promote conservation as well as investment in less wasteful water infrastructures. • Inform and improve land-use planning by understanding the respective water footprints and sustainability of different land uses, allocating water and water-related funding more efficiently. • In countries where needed, implement company or national drought plans including green, blue and grey water footprint analysis in time and space as well as additional measures. • Development of a water-saving culture through an active awareness-raising policy (information, education and training). WF can serve as an awareness raising tool as well as an indicator of the water savings. • Boost investments in research and development for the improvement of knowledge and data collection.	• WF provides additional information to the traditional water accounting scheme, which includes blue water withdrawal within the country. • WF incorporates not only blue water (from the consumption perspective) but also the green and grey water components. • Besides, WF includes another dimension to IWRM, which is the virtual water trade. • This information makes the water footprint a comprehensive sustainability indicator on water resources. • WF can inform production decisions related to the productivity and comparative advantage of the different commodities in terms of water. • WF can provide additional information to national drought plans. • Product transparency is a precondition for consumers to be able to make well-informed decisions on what to buy. Information on the WF can increase awareness about the huge volume of water used to produce different food items and about related environmental impacts.
Agriculture	Minimize the water footprint while ensuring national food security (ensuring everyone has enough to eat), which does not have to be necessarily through food self-sufficiency (growing it all yourself): • Do not subsidise water-intensive agriculture in water-scarce areas. • Promote crops that are suitable and adapted to the local climate in order to reduce irrigation demand. • Promote farmers to avoid or reduce the use of fertilisers, pesticides and insecticides or to better apply so that fewer chemicals reach the water system. • Develop National Irrigation Plans including measures for the modernisation of existing irrigation schemes as well as for the introduction of irrigation systems and techniques that conserve water.	• WF provides location and time specific information on the challenges (blue water consumption and grey water pollution) and opportunities (green water consumption) of the different crop production. • WF of the different systems and techniques can be compared to inform and optimize decision making.

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SCALE Policy sector	National	Role of water footprint
Energy	• Study the implications of energy scenarios for water demand informed by the WFs of different energy carriers • Harmonise water and energy policies so that energy policies do not increase the water footprint of the energy sector and that water policies do not increase the energy use and carbon footprint of the water sector. • Promote biofuels based on waste, residues and non-agricultural feedstock as these have the lowest WFs and do not compete with food production.	• WF provides information on the water consumed and polluted by the different energy types. • WF provides knowledge on the water-energy-food-environment interface.
Environment	• For sustainable production: reduce the water footprint within the nation; focus on hotspots where impacts are largest. • For sustainable consumption: reduce the internal and external water footprint of national consumption; focus on hotspots. • Include water footprint knowledge into the National Water Plans. Including efforts to improve allocative efficiency and technical/ productive efficiency. WF used to inform and monitor allocation efficiency. • Tariff and water pricing systems to affect people's behaviour and promote conservation and efficient water usage. Again WF can be indicator of policy effectiveness • Water markets improve efficiency by creating incentives for farmers and/or industries to save water and sell off their rights to the portions they do not use. They tend to function well in water-scarce basins where large-scale users are engaged in high-value activities. Many countries however lack the preconditions necessary for successful water markets. • Taxes can be applied directly to water used by volume, and could also potentially be applied to products involving highly water consumptive or water polluting processes (in which case they can be viewed as a charge that passes the environmental costs on to the consumer in the absence of detailed knowledge on which to base pollution charges). They could also potentially be used to reduce agricultural water pollution, thereby improving efficiency, by increasing the prices of fertilizers and pesticides; in these cases, they can be viewed as a charge for services not taken into account when the market establishes prices for such inputs. However, all of these options need to be considered carefully in relationship to the larger economy. • Education and communication, including programmes to work with users at school, community and institutional levels. • Promote an international water pricing protocol.	• The WF provides a spatially and temporally explicit measure of the amount of water consumed and polluted by the different socio-economic sectors. • Green, blue and grey WF hotspots can be identified in space and time. Green WF hotspot occurs when the re-allocation of the green evaporative flow from natural to productive vegetation takes place at the cost of biodiversity beyond a certain acceptable level. Blue WF hotspot occurs when the environmental flow requirements in the catchment are violated due to high blue water footprints. Grey water footprint hotspot occurs when ambient water quality standards in the catchment are violated. • Water scarcity can be calculated as the ratio of the WF in the catchment and the water availability.
Foreign and development cooperation	• Cooperate with governments and other agents in developing countries to reduce water footprints; focus on hotspots in the world where water scarcity and pollution problems are most severe and where the nation contributes through its own external water footprint.	• WF provides spatially and temporally explicit information. The blue WF map that can be overlaid with a water scarcity map to identify the high risk areas or hotspots. Idem for the grey WF and pollution map.

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SCALE Policy sector	National	Role of water footprint
Industry	**Supporting / forcing businesses:** • To develop corporate water footprint reporting. Report water-related efforts, targets and progress made in annual sustainability report, also covering the supply-chain. • To develop business water certification. **Promoting product transparency** • Explore the possibility of expanding existing labeling schemes whenever appropriate in order to promote water efficient devices and water-friendly products. Through promoting for instance a water label for water-intensive products. • Through water-certification of businesses. **Foster water efficient technologies and practices** • Consider developing standards for water-using devices such as irrigation systems and other farm energy-using equipments. • Consider developing legislation to cover non-energy-using products including water-using devices (taps, shower heads, toilets). • Include water efficiency criteria in performance standards for buildings. • Consider developing national or international legislation for water performance of buildings. This could cover taps, showers and toilets and reuse of «grey water». • Encourage enhanced research on adaptation of economic activities to water scarcity and droughts, water efficiency and decision-making tools. • Encourage the adoption of binding performances for new buildings and for public and private networks, with systems of fines for excessive leakages. • Develop voluntary agreements with all economic sectors that need water (farmers, builders, building managers, manufacturers, tourism professionals, local authorities) to develop more water-friendly products, buildings, networks and practices.	• Companies have traditionally focused on water use in their operations, not in their supply-chain. The water footprint does take an integrated approach. Most companies will discover that their supply-chain water footprint is much larger than their operational water footprint. As a result, companies may conclude that it is more cost effective to shift investments from efforts to reduce their operational water use to efforts to reduce their supply-chain water footprint and associated risks. • Companies have traditionally looked at reduction of water withdrawals. The water footprint shows water use not in terms of withdrawal but in terms of consumption. Return flows can be reused, so it makes sense to specifically look at consumptive water use. • It is useful to look into the spatio-temporal details of a company's water footprint, because details on where and when water is used can be used as input to a detailed water footprint sustainability assessment, to identify the environmental, social and economic impacts and to find out associated business risks. • Companies have traditionally looked at meeting emission standards. The grey water footprint looks at the required water volume for assimilating waste based on ambient water quality standards. Meeting emission standards is one thing, but looking at how effluents actually result in reduced assimilation capacity of ambient freshwater bodies and at business risks associated to that is another thing.
Trade	• Reduce export of low-value water-intensive products from water-scarce areas (and increase import). • A water scarce nation can save water by importing a water-intensive commodity instead of producing it domestically.	• Water footprint and virtual water trade information can be the basis for making well-informed trade decisions, which can be useful to mitigate water scarcity or buffer droughts.
Urban water supply	• Reliable and sustainable financing to expand and maintain adequate water supply and sanitation services.	• The WF provides spatially and temporally explicit information of the amount of water consumed and polluted. This allows comparing different infrastructures, technologies, devices and practices.
Integrated policy	• Since water is a cross-cutting issue the above mentioned policies should be coordinated and harmonized. • Improve governance structures that encourage coordination of local, national, regional and international resources.	• The new dimensions of the WF (blue, green, grey components and indirect water use – virtual water trade) show the inter-linkages between the different sectors.

SCALE **Policy sector**	**River basin**	**Role of water footprint**
Water	• Use information on water footprints and virtual water trade to support the formulation of river basin plans. • Increase the water use efficiency at the river basin level by allocating water resources to the purposes with highest societal benefit. • Allocate water more efficiently by improving land-use planning. • Implement a ban on increases in water abstraction in overexploited areas. • Assess the volumes that can be sustainably abstracted. • Review the abstraction authorisations. • Obligation to put in place collective irrigation organisations in charge of limiting and distributing abstraction volumes among irrigators. • Improvement of water infiltration into the soil and progress towards soil saturation will help restore groundwater and surface water resources maintaining and increasing organic matter in the soil (EC, 2007).	• WF provides additional information to the traditional statistics on water use, which focuses on blue water withdrawal within the country. • WF incorporates not only blue water (from the consumption perspective) but also the green and grey water. • Besides, WF includes another dimension to IWRM, which is the virtual water trade (indirect water use). • WF can provide complementary information to water withdrawal and better inform decisions. It is therefore interesting to include the WF framework in the river basin management plans. • WF can inform production and allocation decisions related to the productivity and comparative advantage of the different commodities in terms of water.
Agriculture	• Promote water footprint reduction in agriculture at the local level. This can be done in various alternative or complementary ways: regulation or legislation (e.g. on timing, volumes and techniques of irrigation and on application of chemicals), water use licenses, quota, full-cost water pricing, tradable water use permits, and/or subsidies for specific irrigation techniques. • Engage with farmers. • Allocate water where its value added is highest. • Maintain environmental flows, and the additional demand for water presented by biofuels must be managed within a framework that prioritises basic social and environmental needs. • Do not promote projects on afforestation / reforestation activities or bio-energy crops where they are not sustainably located, designed and managed since they can have considerable negative side effects, such as increased water requirements (Bates et al., 2008).	• WF provides location and time specific information on the challenges (blue water consumption and grey water pollution) and opportunities (green water consumption) of the different crop production. • WF of the different systems and techniques can be compared to inform and optimize decision making.
Environment	• Include a water footprint and virtual water trade analysis for the different socio-economic sectors within the river basin management plans. Water footprint accounting provides transparency and a conceptual framework for envisioning water consumption in a basin and identifying areas to target for improved efficiency. • Water footprint knowledge could also be included within Drought Management Plans and within Groundwater Management Plans. • Cooperation and informed decision-making at a river basin level between sub-basins -upstream, midstream, downstream – based on water footprint information and sustainable yields. • Implement water footprint reduction measures ensuring environmental flow requirements. • Plan water allocation taking into account the environmental water requirements. For this purpose it would be very useful to obtain clear data on environmental water requirements and to compare them with the water footprint assessment.	• The WF provides a spatially and temporally explicit measure of the amount of water consumed and polluted by the different socio-economic sectors. • Green, blue and grey WF hotspots can be identified in space and time. Green WF hotspot occurs when the re-allocation of the green evaporative flow from natural to productive vegetation takes place at the cost of biodiversity beyond a certain acceptable level. Blue WF hotspot occurs when the environmental flow requirements in the catchment are violated. Grey WF hotspot occurs when ambient water quality standards in the catchment are violated. • Water scarcity can be calculated as the ratio of the WF in the catchment and the water availability.

SCALE **Policy sector**	**River basin**	**Role of water footprint**
Integrated policy	Promote multidisciplinary, integrated watershed management: • Development and implementation of integrated land and water resource management plans. • Holistic management arrangement that considers multiple users and sectors, prioritising essential social and environmental needs alongside agricultural and industrial needs. • Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.	• The new dimensions of the WF (blue, green, grey components and indirect water use – virtual water trade) show the inter-linkages between land and water and the different sectors.

SCALE **Policy sector**	**Local**	**Role of water footprint**
Water	**Financing water efficiency** • Investments in infrastructure related to water management (e.g. treatment), clean and water-efficient technologies as well as risk prevention measures. • Develop or refine existing strategic guidelines for water infrastructures and in the context of the regional and rural development policies, determine whether further progress needs to be made as regards environmental preconditions related to effective water management before support can be given to any additional water supply infrastructure or equipments. • Explore how sectoral policies could better and further contribute to effective water management, utilising associated funds to foster the delivery of environmental services by water users in an efficient way. • Ensure efficient use of international and national funds to improve water demand management, in particular through measures of adaptation, sustainable practices, more water savings, monitoring systems and adapted risk management tools. • Develop fiscal incentives for the promotion of water-efficient devices and practices, in particular in water scarce areas, taking into account the social context and the potential regional differences. For instance, putting in place waste water reuse equipment in private and public buildings or aquifer recharge; developing schemes that enable businesses to claim allowances for investments in water efficient technologies and equipments; both regional and local authorities and the private sector have sometimes put in place specific action plans in order to support the use of water saving devices and improve water supply networks.	• The WF provides spatially and temporally explicit information of the amount of water consumed and polluted. This allows for comparison of different infrastructures, technologies, devices and practices. • WF can inform production decisions related to the productivity and comparative advantage of the different commodities in terms of water. • This can help lowering the water demand or reallocating limited water to more valued uses, making the water footprint an excellent demand management tool. • Product transparency is a precondition for consumers to be able to make well-informed decisions on what to buy. Information on the WF can increase awareness about the huge volume of water used to produce different food items and about related environmental impacts.

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SCALE **Policy sector**	**Local**	**Role of water footprint**
Water	**Awareness raising** • Further encourage the development of educational programmes, advisory services, exchanges of best practices and large targeted campaigns of communication focused on water quantity issues. • Different measures could be developed such as actions for communication and education in order to increase public awareness on water quantity issues: information campaigns at national, regional or local level; school competitions on water efficiency; free advice to the business sector; a website that is updated daily; inclusion of water issues in educational programmes and development of actions at school to promote water saving devices; development of a national strategy to educate consumers on efficient water use; exchange of good practices on irrigation.	
Agriculture	**Green water footprint in crop growth** • Increase land productivity (yield, ton/ha) by improving agricultural practice; since the rain on the field remains the same, water productivity (ton/m3) will increase and the green water footprint (m3/ton) will reduce. As a result of increased production, less needs to be produced elsewhere, releasing the claims on land and (green or blue) water resources elsewhere. Reducing the green water footprint per ton of crop in one place can thus result in a reduction of the blue water footprint in crop production as a whole. • Conversion of agricultural land into forest/agro-forestry systems in order to achieve the conservation of high-value water bodies and protection of quality water (EC, 2008). • Reduced tillage, which promotes increased water-use efficiency (Bates et al., 2008) **Blue water footprint in crop growth** • Shift to an irrigation technique with lower evaporation loss. • Choose another crop or crop variety that better fits the regional climate, so needs less irrigation water. • Increase blue water productivity (ton/m3) instead of maximising land productivity (yield, ton/ha). • Improve the irrigation schedule, i.e. optimise timing and volumes of application. • Irrigate less (deficit irrigation) or not at all. • Reduce evaporation losses from water storage in reservoirs and from the water distribution system (e.g. pipelines to replace open irrigation channels (Bates et al., 2008). • Respect or compliance with authorisation procedures for using water for irrigation in order to meet water quantity concerns (EC, 2008). • Create incentives to the water user: water pricing, promoting technology, awareness raising. • Use of organic mulches to reduce evaporation (Allen et al., 1998).	• WF provides location and time specific information on the challenges (blue water consumption and grey water pollution) and opportunities (green water consumption) of the different crop production. • WF of the different systems and techniques can be compared to inform and optimize decision making.

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SCALE **Policy sector**	**Local**	**Role of water footprint**
Agriculture	**Grey water footprint in crop growth** • Apply less or no chemicals (artificial fertilisers, pesticides), e.g. organic farming. • Apply fertilisers or compost in a form that allows easy uptake, so leaching is reduced. • Optimise the timing and technique of adding chemicals, so that less is needed and/or less leaches or runs off. • Improved soil management practices (e.g. catch crops) to contribute to the reduction of losses of different compounds to water, including phosphor (EC, 2008). • Establishment of buffer strips along water courses in order to partly retain environmental benefits from set-aside and to contribute to water quality (EC, 2008).	
Industry	**Operations** • Benchmarking products or sites. Define best practice and formulate targets to achieve best practice throughout the business. Can be done in own company or within a sector as a whole. • Reduction of blue water footprint in general. Reduction of consumptive water use in operations by recycling, adopt water-saving appliances, replace water-intensive by water-extensive processes. Leakage detection and minimization. • Reduction of blue water footprint in hotspots. Focus above measures in water-scarce areas or in areas where environmental flow requirement in a river are violated or where groundwater or lake levels are dropping. • Reduction of grey water footprint in general. Reduce waste water volume; recycle chemicals. Waste water treatment before disposal. • Reduction of grey water footprint in hotspots. Focus above measures in areas where ambient water quality standards are violated. **Supply chain** • Agree on reduction targets with suppliers. • Shift to other supplier. • Get more or full control over the supply chain. Change business model in order to incorporate or get better control over the supply chain. **End use** • Reduce inherent water requirements in use phase. Reduce expected water use when product is used (e.g. dual flush toilets, dry sanitation equipment, water-saving showerheads, water-saving washing machines, water-saving irrigation equipment). • Reduce risk of pollution in use phase. Avoid or minimise the use of substances in products that may be harmful when reaching the water (e.g. in soaps, shampoos). • Reducing food loss and wastage in every stage (from farmers' field to consumers) lessens water needs in agriculture.	• Companies have traditionally focused on water use in their operations, not in their supply-chain. The water footprint does take an integrated approach. Most companies will discover that their supply-chain water footprint is much larger than their operational water footprint. As a result, companies may conclude that it is more cost effective to shift investments from efforts to reduce their operational water use to efforts to reduce their supply-chain water footprint and associated risks. • Companies have traditionally looked at reduction of water withdrawals. The water footprint shows water use not in terms of withdrawal but in terms of consumption. Return flows can be reused, so it makes sense to specifically look at consumptive water use. • It is useful to look into the spatio-temporal details of a company's water footprint, because details on where and when water is used can be used as input to a detailed water footprint sustainability assessment, to identify the environmental, social and economic impacts and to find out associated business risks. • Companies have traditionally looked at meeting emission standards. The grey water footprint looks at the required water volume for assimilating waste based on ambient water quality standards. Meeting emission standards is one thing, but looking at how effluents actually result in reduced assimilation capacity of ambient freshwater bodies and at business risks associated to that is another thing.

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SCALE **Policy sector**	**Local**	**Role of water footprint**
Industry	**Product & business transparency** • Conform to shared definitions and methods. Promote and adopt globally shared definitions and methods of water footprint accounting and sustainability assessment. • Promote water accounting over the full supply chain. Cooperate with others along the supply chain to be able to produce full accounts for final products. • Corporate water footprint reporting. Report water-related efforts, targets and progress made in annual sustainability report, also covering the supply-chain. • Product water footprint disclosure. Disclosure of relevant data through reporting or internet. • Product water labeling. Same as above, but now putting the information on a label, either separate or included in a broader label. • Business water certification. Promote and help setting up a water certification scheme and conform to it. **Business engagement with consumers and civil society organisations** • Consumer communication. **Business engagement with governments** • Pro-actively work with governments on developing relevant regulation and legislation.	
Urban water supply	• Water saving technologies and water conservation measures for households and for public/urban usage: - Waterless toilets (e.g. compost & dry) - Water-saving toilets (e.g. single low flush, dual flush) - Water-saving urinals - Waterless urinals - Water-saving taps - Water-saving showerheads - Pressure reducers - Water-saving household appliances (e.g. washing machine, dishwasher) - Economised water use for personal hygiene - Economised water use for cleaning and watering. - Piped water networks - Pressure management and metering for reducing leakages - Dual quality supply networks for limiting the consumption of scarce drinking-quality water (supply with two types of water qualities). • Waste water treatment technologies to enhance reuse and cascading use: - On-site treatment of grey water - Constructed wetlands for treating domestic waste water. - On-site and near-site treatment of black water and mixed sewage. - Environmentally sound centralized sewage treatment in developing countries for reuse. • Leakage detection and minimization. • Demand side management. • Water efficient/neutral town development and urban planning. Public sector water utilities: • Commitment to effectively monitored performance targets (e.g. leakage reduction) • Tariff reform to improve cost recovery • Use benchmarking	• The WF provides spatially and temporally explicit information of the amount of water consumed and polluted. This allows to compare different infrastructures, technologies, devices and practices.

2.5 Gaps in knowledge and suggestions for further work

In this section we identify the areas within the water footprint field where further research on science and the science-policy interface is needed. A summary is included in Table 2.

2.5.1. Accounting for virtual water trade in policy making

The current global trade pattern significantly influences water use in most countries of the world, either by reducing domestic water use or by enhancing it. Future national and regional water policy studies should therefore include an assessment of the effects of trade on water policy. For water-scarce countries, it would also be wise to do the reverse: study the possible implications of national water scarcity on trade. In short, strategic analysis for water policy making should include an analysis of expected or desirable trends in international or inter-regional virtual-water flows (Hoekstra, 2010).
International agreements on the liberalization of trade in agricultural products – as being negotiated in WTO's ongoing Doha Development Round – should include provisions that promote sustainable water use in agriculture. As yet it is unclear how such provisions could look like, since the WTO explicitly refrains from making environmental agreements. An imbalance in global regulations of trade will be created as soon as free trade agreements are effective while sustainable-product and sustainable-water-use agreements to constrain international trade are not yet existent. This is a serious risk, since no international agreements on sustainable water use or sustainable products do exist or are being prepared (Hoekstra, 2010).

2.5.2. Water footprint of forestry

The water footprint of forestry deserves further attention. Better understanding is needed of the effects of afforestation and deforestation on the processes in the hydrological cycle, such as rainfall, evapotranspiration, runoff, infiltration and groundwater recharge.

2.5.3. Developing countries

The developing country policy context deserves particular attention and should be further analysed. Many developing countries lack the appropriate infrastructure and institutions to manage water effectively. The development of institutions, technologies and capacity to manage water among competing users is fundamental. Furthermore in these countries the focus is on achieving the right to safe water and sanitation (and the right to food) target of the Millennium Development Goals while at the same time learning from the experience of developed countries and leapfrogging polluting and water inefficient development stages.

It is clear that the water footprint can help developing countries in various ways starting by providing water use data at the catchment, river basin and country level which generally does only very rudimentary exist in developing country contexts. The focus of UNEP WAFNE project on applying the water footprint in the contexts of developing countries will be an invaluable testing ground for understanding other opportunities but also constraints associated with the water footprint methods and data.

2.5.4. Water footprint offsetting

The concept of water footprint offsetting is still ill-defined (Hoekstra et al., 2009). In general terms it means: taking measures to compensate for the negative impacts of the water footprint that remains after reduction measures have been implemented. But the two weak points in the definition are that (1) it does not specify which sort of compensation measures and which level of compensation are good enough to offset a certain water footprint impact and (2) it does not specify which impacts should be compensated precisely and how to measure those impacts. In the previous chapter we have seen that the term 'impact' can be interpreted very broadly. The fact that the offset concept is ill-defined means that it can easily be misused. Without a clear definition, measures taken under the banner of 'offset' can potentially be a form of green-washing rather than a real effort aimed at full compensation. For this reason, we strongly recommend to focus response on the step of avoiding and reduction of water footprints and to look at offsetting as a real last step only. Another reason is that water footprints and their associated impacts are always local. In this respect, the water footprint is markedly different from the carbon footprint. The idea of a global offset market as has developed over the past few years for carbon footprint offsets does not make sense for water. An offset of a water footprint should always occur in the catchment where the water footprint is located. This drives the attention to the own water footprint again and does not allow to think in terms of general compensation schemes where one can simply 'buy' an offset. In practice, the Coca Cola Company in order to gain a better understanding of the watershed restoration benefits has assessed and already developed several Community Water Partnership Projects (LimnoTech, 2009).

Several offsetting measures are presented below:

- Environmental compensation. Invest in improved catchment management and sustainable water use in the catchment where the company's (residual) water footprint is located. E.g. Wetland restoration: Conversion of agricultural land into forest/agro-forestry systems (EC, 2008).
- Social compensation. Invest in equitable water use in the catchment where the company's (residual) water footprint is located, e.g. by poverty alleviation and improved access to clean water supply and sanitation.
- Economic compensation. Compensate downstream users that are affected by intensive upstream water use in the catchment where the company's (residual) water footprint is located.
- Corrective measures include cease and desist orders, compensation for damage and economic losses, and abatement and re-mediation requirements. The polluter pays principle allocates responsibility for damage costs.

2.5.5. Water neutrality

Closely related to the concept of water footprint offset is the idea of water neutrality. Water neutrality is the umbrella term for avoiding, reduction and offsetting. It carries similar problems as the concept of water footprint offsetting. We will not use it in this section and recommend others to give priority to set quantitative targets with respect to the reduction of water footprints and associated impacts rather than using terms like offsetting and neutrality. And when the terms are used nevertheless, one should take extreme care to clarify what is meant precisely.

'Water neutral' means that one reduces the water footprint of an activity as much as reasonably possible and offsets the negative externalities of the remaining water footprint (Hoekstra et al., 2009). In some particular cases, when interference with the water cycle can be completely avoided – e.g. by full water recycling and zero waste – 'water neutral' means that the water footprint is nullified; in many other cases, like in the case of crop growth, water consumption cannot be nullified. Therefore 'water neutral' does not always mean that water consumption is brought down to zero, but that the negative economic, social and environmental externalities are reduced as much as possible and that the remaining impacts are fully compensated. Compensation can be done by contributing to (investing in) a more sustainable and equitable use of water in the hydrological units in which the impacts of the remaining water footprint are located.
Water neutral is a strong concept in the sense that it attracts broad interest, invites for positive action and sounds good. Some companies like the concept for that reason. The water-neutral concept offers a great opportunity to translate water footprint impacts into action to mitigate those impacts within both communities and businesses. However, there are a number of important questions that need to be answered clearly as a precondition for the success of the water-neutral concept. These are for example: How much reduction of a water footprint can reasonably be expected? What is an appropriate water-offset price? What type of efforts count as an offset? As long as these sorts of questions have not been answered yet – the risk of the water neutrality concept is that its content depends on the user. As a result, some may use it to refer to real good measures taken in both operations and supply chain while others may use it in a way that can rather be interpreted as a way of 'green-washing'. The risk with the water-neutral concept is also that the focus will shift from water footprint reduction to offsetting. A water footprint can be measured empirically, so can its reduction. Defining offsetting and measuring its effectiveness is much more difficult, enlarging the risk of misuse. Besides, compensating measures should be considered a last resort option, to be looked at after having reduced the own water footprint first.

Table 2 Water footprint: Gaps in knowledge and suggestions for further work

Gaps in knowledge	Suggestions
Accounting for virtual water trade in policy making	Accounting for water in the rules of international trade (WTO, EU) as a mechanism to improve global water efficiency based on water productivities and comparative advantage in water.
Land-use change implications in water resources quantity and quality	Further research on the water footprint of different land uses across time, including reforestation activities.
Developing country policy context	Further research on the water footprint and virtual water trade in developing countries and comparative analysis between developed and developing contexts.
Water footprint offsetting	Research on the concept and applications: better understanding and agreement.
Water neutrality	Research on the concept and applications: better understanding and agreement.

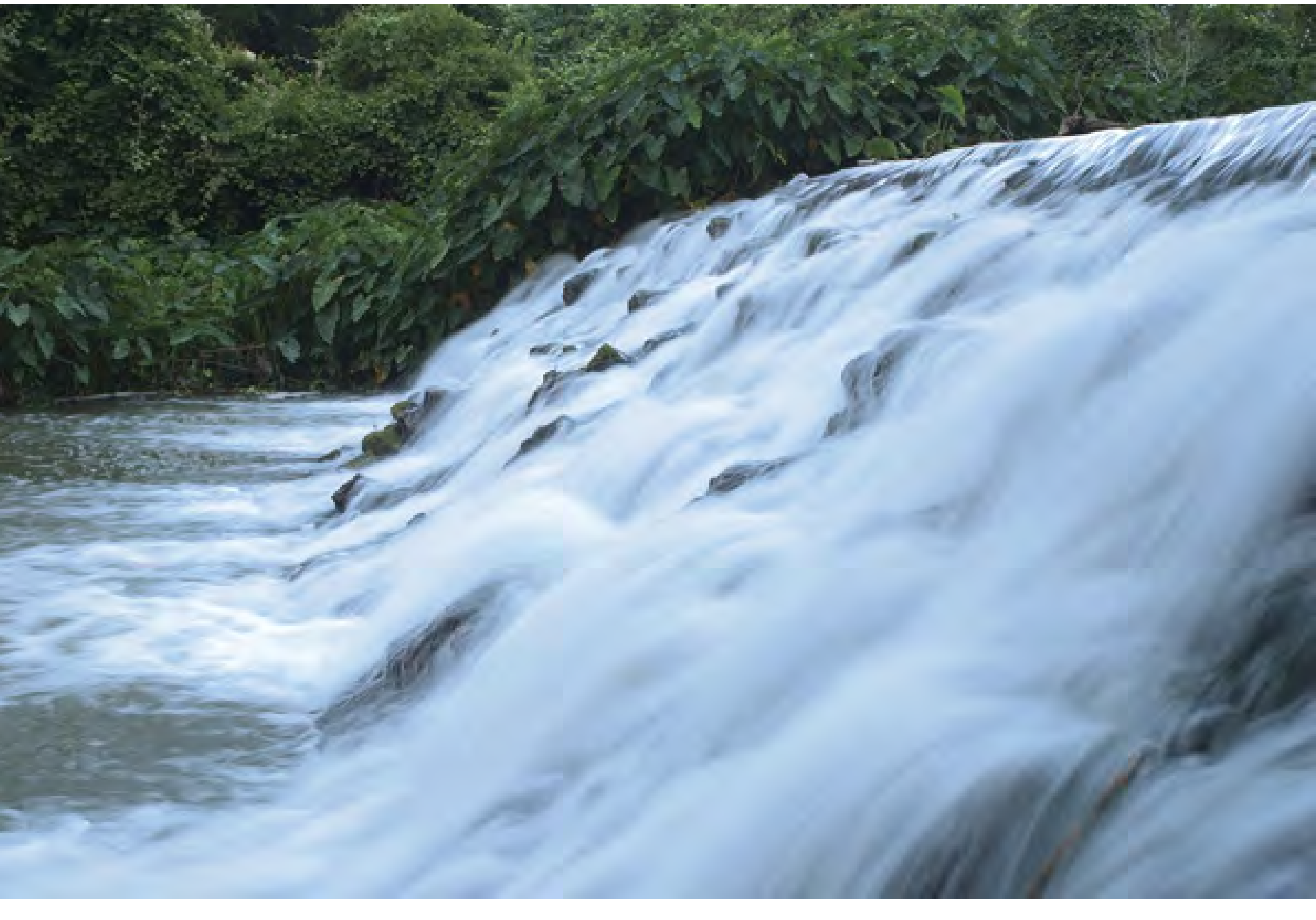
2.6. Conclusions

Water footprint assessments at different geographic levels can be used to inform cross sectoral policy making, build citizen awareness, evaluate policy and measures outcomes and inform water allocation decisions at different levels.

Part 2 presents a long list of policy and practical measures for achieving more sustainable water use across different geographic and institutional scales as well as across a variety of policy sectors. Apart from the need to understand several policy measures in more detail, the main question is how to come to the most effective and efficient policy / measure mix to further sustainable water management. Currently no systematic and practical framework exists to do this.

As mentioned in part 1, the Water footprint provides a common language to express water use from the production and consumption perspectives in different contexts. Part 2 clearly shows that different policy and practical measures might be understood and evaluated on their merits for sustainable water management by using the water footprint as a common water use indicator. However, as mentioned above, no systematic and practical framework exists to do this.

Further research and development work as well as debate is required to come to a better understanding and agreement on water offsetting and water neutrality. Deeper understanding is also required in how the notion of virtual water could enhance the sustainability of trade especially in the negotiation in the Doha Development round of the WTO. Part 2 takes a lot of information from the developed country context, however the most pressing water related problems do exist in the developing world. It is envisaged that water footprint can greatly inform evaluate policies in developing countries, however, no tangible work on this has been executed until now.



Part 3: A practical water footprint assessment guideline

3.1. Introduction

The purpose of part 3 of this report is to contribute to the development of the Water Footprint manual (Hoekstra et al., 2009). The main contribution is the presentation of a practical guideline for water footprint assessment of a specific geographical area. The guideline is meant to structure the data collection and analysis in the four steps of the water footprint assessment procedure (Hoekstra et al., 2009). This guideline is informed by Part 1 and Part 2 of this report. The geographic scope of the guideline is any geographic area. It concerns:

- the water footprint(s) within a geographically delineated area (WF_{area}),
- the water footprint(s) of consumption in the geographical area ($WF_{cons,\ area}$).

Part 3 starts with presenting the data points of the four phases of water footprint assessment. Then the practical guideline for the four phases is presented. It ends with research and development topics and conclusions.

3.2 Geographical water footprint assessment data

This chapter provides an overview of the data that are collected in the four phases of WF assessment based on manual (Hoekstra et al, 2009), the case studies (Part 1) and the policy measures (Part 2). All four phases of the water footprint assessment will be addressed.

3.2.1 Scope and goal

As in any WF assessment, first phase addresses the scope and goal. There are no data gathered in this phase, instead scope and goal are set in a narrative way. For this report, the geographic scope is any clearly delineated geographical area, e.g. a nation, state, province or municipality or a river basin or catchment area.
This scope encompasses all varieties of geographical areas and scales that can be thought off. There is one exception and this is the global scale. The global scale is different from the lower level geographic scales. At global level, the water footprint within the area equals the water footprint of consumption of the area. In other words, the sum of all global process water footprints (WF_{global}) equals the water footprint of global consumption ($WF_{cons,\ global}$). The reason for this is that virtual water trade does not occur beyond the global scale. So when virtual water trade is addressed, it will only refer to geographic scales lower than the global scale.

The water footprint assessment can also focus on different levels of aggregation of water use and users in a specific geographical area.

The scope also identifies the levels of aggregation of water footprint calculation of the different water uses or users in a specific geographical area. For instance, a water footprint assessment of a geographical area can have a focus on the main water using sectors: agriculture, industry and domestic. This scope leads to the aggregation of water footprint calculations to the sectors of agriculture, industry and domestic use. The main water user sectors can in turn be disaggregated in subsectors, individual water users and even individual processes. Respectively this leads to an aggregation of water footprint calculations to subsectors, individual water users and processes. The case studies show various levels of aggregation and disaggregation of water usage. For example for the agricultural sector, Liu and Savenije (2008) focus on the food production sector and within that a variety of subsectors. Aldaya and Llamas (2008) disaggregate the agriculture water use sector to a long list of horticulture, fruticulture and grain producing sub-sectors. The industrial and domestic water use sectors are kept at an aggregated level. Fraser and Schreier (2007) include golf courses as a water user. Depending on the goal and scope of the study, aggregation and disaggregation of water use can take place. Theoretically, the lowest level of disaggregation is to present all process water footprints for a specific geographic area. The highest level of aggregation is the total water footprint of all water uses of a specific geographic area.

For the guideline that is presented later in section 3.3, the scope is set to the three main water user sectors, agriculture, industry and domestic use. The reason for this is presentational. And, as pointed out above, this scope can be adapted according to the goal and scope of the water footprint assessment.

The inventory of the case studies shows a variety of goals (see annex 1) for footprint assessment at geographical scale that can be summarised as increasing the sustainability of:

- the water footprints within the geographic area
- the water footprints of consumption of the people living in the geographic area.

Goal one is related to local water resource management. Goal two captures not only the water footprint of people in the area in which they live but brings in the external water footprint as well, i.e. the water footprint outside the area considered. Looking from the geographic perspective, the second goal concerns the sustainability of the external water footprint or the virtual water import into the specific geographical area. It is therefore a sustainable trade goal. The two goals are intimately related as sustainable local water use has the potential to increase the sustainability of virtual water exports. Also the sustainability of virtual water imports can increase the sustainability of the water footprint as can be seen later on in the chapter. The response for increasing the sustainability of virtual water imports can stimulate sustainable water use in the originating localities.

3.2.2. Data in the water footprint accounting phase

In paragraph 1.1.4, it is observed that the national water footprint accounting scheme presented by Hoekstra et al. (2009), applies to all types and scales of geographic areas except the global scale. The national water footprint accounting scheme can be adapted to be a geographic water footprint accounting according to figure 3.1 below.

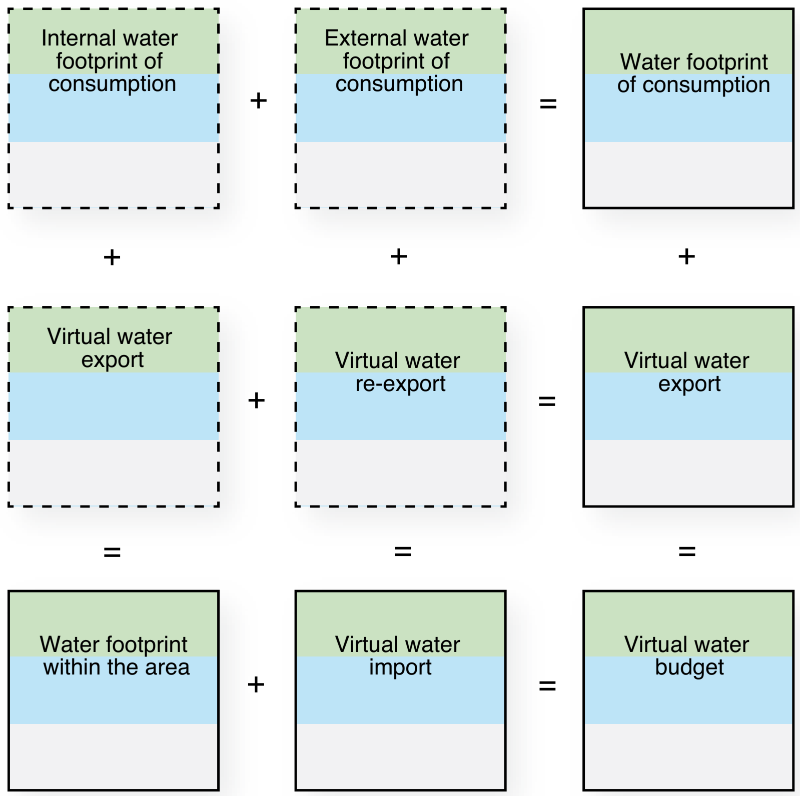


Figure 3.1 Geographic water footprint accounting scheme for a geographical area, the colors green, blue and grey represent the green, blue and grey elements of the water footprint. Adapted from Hoekstra et al. (2009)

The water footprint components in the accounting scheme can be divided in two groups, components addressing internal water footprints alone and components addressing external footprints alone. Internal water footprint components:

- Water footprint within the area (WF_{area})
- Internal water footprint of consumption in the area ($WF_{cons,area,\ int}$)
- Virtual water export related to products made in the area ($V_{e,\ d,\ area}$)

External water footprint components:

- Virtual water import (V_i)
- External water footprint of consumption in the area ($WF_{cons,area,\ ext}$)
- Virtual water import for re-export ($V_{e,\ r,area}$)

Please note that all data on the water footprint components do specify the green, blue and grey components. Following the equations in the manual (Hoekstra et al., 2009) these data can be used to fill out the entire geographic water footprint accounting scheme (figure 3.1).

3.2.3. Data in the water footprint sustainability assessment phase

> Environmental indicators

Blue water scarcity

In the manual blue water scarcity in an area is calculated by dividing the blue water footprint (WF_{blue}) by the blue water availability within the area (WA_{blue}). Blue water availability (WA_{blue}) is calculated by subtracting the environmental flow requirement (EFR) from the runoff (*R*) . Blue water scarcity provides an indication of the degree of violation or non violation of the environmental flow requirements. And thus blue water scarcity can serve as a measure of environmental impact (Hoekstra et al., 2009). In this sense, blue water scarcity might be more appropriately named blue "environmental" water scarcity.

Only the Doñana case study uses blue environmental water scarcity as defined above (Aldaya et al., 2009). Two other studies use a blue water balance approach that does not take into account environmental flow requirements (see 1.2.3). Generally, runoff data are available as it is the most basic hydrological parameter although data accuracy can be challenged (Gleick et al., 2006). Availability of data on environmental flow requirements is low. The main reasons for this seems to be that the process of establishing an environmental flow requirement is money and labour consuming. Also, it is the outcome of a socio-political negotiation process. In this process decisions need to be made about the condition in which aquatic ecosystems and their services are maintained (Eflownet www.eflownet.org). It will take at least a decade before enough EFRs are established to calculate the blue environmental water scarcity worldwide. Thus there is an urgent need for an agreed simple and globally applicable method for environmental flow requirements (Hoekstra et al., 2009).

Green water scarcity

Hoekstra et al. (2009) explain that green water scarcity indicates the degree of replacement of green evaporative flow from natural vegetation to productive vegetation for human use (crops for food, fuel, fibers or wood for timber, paper of fuel) at the cost of terrestrial biodiversity. Following this reasoning, the indicator denotes the amount of water no longer benefiting natural terrestrial vegetation in a geographic area. It thus captures the biodiversity and intrinsic ecosystem values of the natural terrestrial vegetation. However, natural vegetation also plays a role in watershed hydrology and water quality. The type of vegetation influences evaporation, transpiration, soil water holding capacity, infiltration, groundwater flow and rapid, stable runoff and even cloud formation. Replacing natural vegetation by other vegetation can cause a change in all of these hydrological processes. None of the case studies presented in Part 1 have data on green water scarcity. To understand the green water scarcity, the role of natural vegetation for watershed hydrology and water quality within the watershed needs to be better understood.

Water Pollution Level

Hoekstra et al. (2009) present the Water Pollution Level (WPL) as an indicator of the degree of pollution of water flow. WPL is obtained by dividing the grey water footprint (WF_{grey}) by the Runoff (*R*) in a certain catchment (*x*) over a certain time (*t*). None of the case studies calculated the WPL. Only the Doñana case study presents data on the grey water footprint and Runoff that allows for calculation of the Water Pollution level (Aldaya et al, 2009).

> Economic indicators

Part 1 presents water productivity (FAO, 2010) as the economic indicator that is used in most of the case studies. Water productivity can be expressed as physical water productivity (ton/m^3) and economic water productivity (EWP, Euro/m^3). The data required to calculate water productivity is the volume of product output and economic value of the volume of product output. In the case of agriculture, product output is equal to yields for a certain crop. Physical water productivity and economic water productivity as efficiency indicators can be used to understand the level of optimisation of water use in geographic area but also between areas. Hoekstra et al. (2009) argue that care should be taken not to arrive at simplified conclusions on re-allocation of water using the water productivity indicator alone. Not only water is determining water productivity. Other economical and non-economical factors can be at play, like costs of inputs, subsidies, the level of change in productivities between regions, social issues like the secure provision of jobs to people and environmental costs and benefits as well.

No indicators are available yet to understand the economic costs of grey water footprints.

> Social indicators

The manual discusses social indicators to be related to issues like equitable sharing of water, external effects of water footprints, free ridership, employment and human health. In the case studies, three social indicators are presented: water footprint per capita (Hoekstra & Chapagain, 2008), the number of jobs per cubic meter (Aldaya et al., 2009) and energetic water productivity in kcal per cubic meter (Liu & Savenije, 2008). As can be seen in Part 1, these three indicators are used to answer very different questions. It is clear that a systematic approach to understand the social benefits and costs of water footprints needs further elaboration and development. This approach should clearly address that social indicators are never solely related to water consumption. Other non-water factors exert influence on any social indicator. Factors like: land tenure, level of governance, empowerment of marginal groups, national development policy and regulations and finance.

It can be argued that any social indicator used to assess the social sustainability of a water footprint needs to link the water footprint to an important social issue directly associated with water. The Comprehensive Assessment of Water Management in Agriculture (2007) presents access to drinking and irrigation water and food production as critically important issues directly associated with water consumption. It seems logical to define social indicators associated with this type of issues. The energetic water productivity indicator used by Liu & Savenije (2008) is an example of a food related indicator.

No indicators have been proposed to understand the social effects the grey water footprints.

> Observations on data in the water footprint sustainability assessment

Sustainability of external water footprints and virtual water imports

The indicators addressed can be used to assess the sustainability of water footprints within the geographical area. As long as data are collected for the geographic area considered only, one cannot assess the sustainability of external water footprints and virtual water imports. External water footprints and virtual water imports are external to the area under assessment. They refer to water consumption outside the area through the imports into the area considered. The national water footprint case studies for the Netherlands, the United Kingdom and Germany do present a proximate assessment of the blue environmental water scarcity as a result of virtual water imports (Van Oel et al., 2009; Chapagain and Orr, 2008; Sonnenberg et al., 2009). The method used is the identification of 'water footprint hotspots' (Hoekstra et al., 2009). A water footprint hotspot is obtained by overlaying the occurrence of water footprint in space and time with the occurrence of water scarcity in the same places and at the same time. The hotspots are identified as places and times where water footprints occur and at times of water scarcity. A water footprint hotspot is qualitative, as it does not present a quantitative relationship of the water footprint with the water scarcity. Therefore, the contribution of a specific water footprint to the local water scarcity cannot be derived from a hotspot. The hotspot is a presentation of the coincidence of water footprints and water scarcity in a certain location at a certain time. There is a need to replace this 'qualitative' environmental impact analysis with quantitative information on the environmental sustainability of virtual water imports.

Theoretically, the sustainability assessment approach for the internal water footprints of an area can be employed for any area on the globe at any scale. Assuming that the data are available, all process water footprints and their associated sustainability indicators can be known for any catchment, district, or country in the world. This means that in theory an indication of the absolute sustainability of all water footprints in all areas around the globe can be produced, if the globe would be our geographic scope. But with a water footprint assessment of an area, the geographic scope is of course a geographically delineated area. At this level, the external water footprint components come into play as per figure 3.1 and 3.2.

The external water footprint of an area has a key characteristic that makes it different from the water footprint within the area (WF_{area}). The water footprint within the area is the sum of all process water footprints within that area. It presents a measure of the total water consumption and pollution within an area. As presented earlier, to understand the sustainability of the water footprint within the area, it can be directly compared with the water available. This is not the case for the external water footprint of an area. The external water footprint is made up of fractions of the total water footprint within the exporting areas (and the virtual water for re-export of course as well). For example, the external water footprint of the Netherlands is made up of the water footprints of cotton, oil products, coffee, and many other products imported from India, South Africa, Sudan and various other countries (Van Oel et al., 2009). In the case of the cotton exports from India, the water footprint of the cotton export to the Netherlands is a fraction of the total water footprint of cotton exports from India. The cotton exports water footprint in turn is a fraction of the total water footprint of India. The sustainability of the water footprint of the cotton exports from India to the Netherlands can be calculated as a fraction of the total sustainability of the water footprint within India. Following the equations for blue and green water scarcity and water pollution level in the manual, this calculation leads to a fraction of the blue and green water scarcity and water pollution level. The value is a measure of the contribution of the cotton imports of the Netherlands to the water scarcity in India. The sustainability of the total external water footprint (and its total virtual water imports) of an area can be understood by summing the water scarcity and water pollution level fractions of its product water footprints. As we have seen, the data for doing this are not yet available. The approach is further explained in paragraph in 3.2.5 where the contribution ratio is presented.

Other methods for understanding the sustainability of external water footprints have not yet been published. In order to provide guidance on the sustainability of external water footprints, an alternative approach can be followed based on the Water Footprint Impact Index (Hoekstra et al., 2009). The Water Footprint Impact Index (*WFII*) for green, blue and grey water footprints can perform a role in the quantification (Hoekstra et al., 2009) of the sustainability of external water footprints. The *WFII* is a weighed measure of the environmental impact of a water footprint. By calculating the *WFII*s for the external water footprints and/or virtual water imports, environmental impacts can be quantified (see the equations in Box 4.4 of the manual, Hoekstra et. al.(2009)). The calculation of the indexes requires the green, blue and grey components of virtual water imports or external water footprints as well as global datasets on green water scarcity, blue water scarcity and water pollution level at the catchment level with a monthly time step. The required global datasets on water scarcity and water pollution level do currently not exist but are expected to become available in the near future.

The *WFII* is a weighed number and thus by definition an index of environmental sustainability that is relative. The index does not give information about the absolute contribution of the water footprint to water scarcity or water pollution. However, the index does give quantitative information on water footprints and their occurrence in water scarce and polluted areas. What this means is best explained by a hypothetical example. Let us assume that Turkey imports rice from Country X with a water footprint of 1000. The rice imports are from an area with a water scarcity of 70%. The *WFII* for these imports is calculated as 1000*70% = 700. If the same amount of rice is imported from Country Y, assuming different climatic conditions, the water footprint is 1200 and water scarcity is 50%. This leads to a *WFII* of 600. The *WFII*s of 700 (X) and 600 (Y) do not say anything about the absolute contribution of rice cultivation to the water scarcity issues in X and Y. The numbers are quantitative values of the relative environmental sustainability of the rice imports by Turkey from both places. By comparing these hypothetical *WFIIs*, Turkey could decide that rice imports from Y are relatively more sustainable than from X. As the *WFII* is relative, theoretically there is potential for comparing *WFII*s of products, commodities, catchments, nations etc to understand their relative sustainability. The *WFII*s do not display information on the economical and social benefits and costs of water footprints. The *WFII* has not yet been applied in practical studies.

3.2.4. Data in the water footprint response formulation

Theoretically, a water footprint response outcome will always be measured as a reduction in the volume of a water footprint at a certain place in a certain time period. Any change in the volume associated with a water footprint of a process will directly change the values of the environmental, social and economic sustainability indicators of that process.

Following the water footprint manual, three subsequent hierarchical steps in water footprint responses have been defined: 1. avoid the water footprint, 2. reduce the water footprint and 3. offset the water footprint (Hoekstra et al., 2009). The manual includes a library of water footprint response options. The long list of policy and practical measures of Part 2 adds to this library from the point of view of the geographical area and multiple sectors. It is beyond the scope of this report to quantify the list of measures in terms of potential water footprint reductions. Instead, as an example, two water footprint reduction strategies within a geographical area are presented below.

Reduction of blue water footprints can potentially be achieved through substitution of a blue water footprint by a green water footprint. As an example, the Comprehensive Assessment of Water Management in Agriculture (2007) states that improved soil management can lead to higher green water availability on farms. In the case of supplementary irrigation, a larger green water availability can decrease the amount of blue water required by the crop. Thus the blue water footprint is reduced by substitution with a green water footprint. The grey water footprint cannot be reduced by substitution by a blue or green water footprint. It is a representation of the pollution load as a volume. It can only be reduced by decreasing the pollutant load (Hoekstra et al., 2009).

Hoekstra and Chapagain (2008) present water saving through virtual water imports as another way to reduce water footprints. Virtual water trade can however result in social and environmental costs (Chapagain and Orr, 2008; Sonnenberg et al., 2009). And, as we have seen there is not enough information available on the sustainability of virtual water trade. Before water saving through trade can be used as a water footprint reduction strategy, the sustainability of the virtual water traded should be evaluated.

3.2.5. Additional aspects
Presenting data for different sectors and users within a geographical area

Water footprint data of sectors and individual users within a geographical area ($WF_{user,\ area}$) can be presented as a contribution *C* to the total water footprint within a geographical area (WF_{area}). The contribution provides information about relative contribution of individual water users or sectors to (1) the water footprint within a geographical area and (2) the environmental and social and economical impacts within the geographical area. The relative contributions of different users and sectors provide information on the equity between different water uses within an area as well as information on the relative contributions of users to the sustainability or non sustainability of water use within the area. The ratio highlights quantitative entry points for response formulation directed at reduction of water footprints within a geographical area. Van Lienden et al. (2010) show an example of this type of calculation by presenting the contribution of the blue water footprint of growing crops for biofuels to the blue water scarcity, per country. The water footprint of a user within a geographical area ($WF_{user,\ area}$) can be calculated by summing all the process water footprints ($WF_{process}$) for the processes *r* of a specific user. A user can be a company or a sector or an individual. The water footprint can be direct or indirect, in operations or supply chain as long as it occurs within the geographical area. The water footprint specifies the green, blue and grey components.

$$WF_{user,area} = \sum_{r} WF_{process}[r]$$

The manual gives the formula for the water footprints within the area (WF_{area}) (Hoekstra et al., 2009) also presented in 1.1.4. WF $_{area}$ is the sum of all the water footprints of processes *q* occurring in the area.

$$WF_{area} = \sum WF_{process}[q]$$

The contribution ratio of a user to the water footprint within an area $C_{user,\ area}$ can be calculated by dividing the water footprint of a user within the area ($WF_{user,\ area}$) by the total water footprint within the area (WF $_{area}$).

$$C_{user,area} = \mathrm{WF}_{user,area} / WF_{area}$$

Similarly, the contribution ratio of a user to the water footprint of consumption of an area, $C_{user,\ cons,\ area}$, can be calculated by:

$$C_{user,cons,area} = \mathrm{WF}_{user,cons,area} / WF_{cons,area}$$

As pointed out in section 3.2.3 on the sustainability of a water footprint, the relative contribution of a water footprint of a user to blue water scarcity (WS $_{blue,area}$), green water scarcity ($WS_{green,area}$) and to the Water Pollution level (WPL_{area}) within an area can be calculated. For this purpose, the equations in box 4.2 and 4.3 of the manual (Hoekstra et al., 2009) are adapted. The contribution of a user to green water scarcity within an area ($WS_{green,user,area}$) is expressed as the ratio of the green water footprint of a user within the area ($WF_{green,user,area}$) divided by the green water availability ($WA_{green,area}$) at time *t*.

$$WS_{green,user,area}[t] = \frac{WF_{green,user,area}[t]}{WA_{blue,area}[t]}$$

The contribution of a user to blue water scarcity within an area ($WS_{blue,user,area}$), is expressed as the ratio of the blue water footprint of a user within the area ($WF_{blue,user,area}$) divided by the blue water availability ($WA_{blue,area}$) at time *t*.

$$WS_{blue,user,area}[t] = \frac{WF_{blue,user,area}[t]}{WA_{blue,area}[t]}$$

The contribution of a user to water pollution level within an area ($WPL_{user,area}$), is expressed as the ratio of the grey water footprint of a user within the area ($WF_{grey,user,area}$) divided by the Runoff (*R)* at time *t*.

$$WPL_{user,area}[t] = \frac{WF_{grey,user,area}[t]}{R_{area}[t]}$$

A global water user will have water footprints that contribute to water scarcity and water pollution in many areas around the globe. The overall sustainability of the water footprint of this user can theoretically be understood by summing the contributions of the water footprints of the user to the green water scarcity ($WS_{green,user}$) and blue water scarcity and water pollution level ($WPL_{,user}$). This is the same approach to understand the sustainability of the external water footprint of an area in paragraph 3.2.3. Three equations are given below to explain this calculation for the total contribution of a user to green water scarcity ($WS_{green,user}$), the total contribution of a user to blue water scarcity ($WS_{blue,user}$) and the total contribution of a user to water pollution level (WPL_{user}) in a number of areas *i* at time *t.*

$$WS_{green,user} = \sum_i WS_{green,user,area}[i,t]$$

$$WS_{blue,user} = \sum_i WS_{blue,user,area}[i,t]$$

$$WPL_{user} = \sum_i WPL_{user,area}[i,t]$$

The approach will need further testing and refinement to understand the new information that these indicators convey. The approach appears to be generically applicable for any type of water footprint. This also needs further research and elaboration. Here only the example for a specific user is given but in a similar way, the contribution to water scarcity of all external water footprints of an area can be calculated or the contribution to water scarcity of the water footprints of consumption of a nation can be calculated.

3.3. Guideline for water footprint assessment data

The preceding section presents an overview of concepts and data that need to be gathered and calculated in a water footprint assessment. This paragraph develops a practical guideline for the water footprint assessment so that data collection and analysis are made easy. This guideline structures the concepts and data presented in the previous section in a simple and practical way. The aim is to facilitate the process of understanding of a complex matter and make the WF assessment process accessible to all kinds of public.

3.3.2. Water footprint accounting

Water footprint data for a specific geographical area are generally calculated for a restricted number of water using sectors, subsectors or individual users. For practical reasons, three aggregated water using sectors are generally used: agriculture, industry and domestic use.
In paragraph 3.2.2. we have seen that the water footprint accounting scheme presents nine water footprint components. Also, two contribution factors have been proposed, $C_{user,\ cons,\ area}$ and $C_{user,\ area.}$ These provide information on the relative contribution of users from various sectors to the water footprint of consumption and the water footprint within an area.

Table 3.1. Information captured in during Phase 1 of the water footprint assessment
Source: Hoekstra et al. (2009)

Scope and goal topic	Specific question
Goal	Why is the water footprint assessment done?
Geographic boundary	Which area and type (city, basin, district, country), what geographic resolution of data is considered?
Temporal boundary	Which period(s) with which time step (year, month)?
Sector boundary	Which sectors will be investigated, to which subsector level, agriculture, urban, domestic use
WF accounting boundary	Will virtual water trade be incorporated? Calculating blue, green and grey water footprint? Where is the analysis truncated in terms of the virtual water imports?
WF sustainability assessment boundary	Focus on environmental (scarcity and WPL) or also social, economic sustainability or all? Calculate impact indicators or weighed indexes or both?

3.3.1. Scope and goals

As can be seen from the previous section Phase 1: setting the scope and goals of the water footprint assessment is a not a quantitative but a narrative exercise. Components of this narrative are well described in the manual and will not be repeated here (Hoekstra et al., 2009). Following the guidance of the manual, table 3.1 presents a tabular overview containing the information required to set the goal and scope of a water footprint assessment within an area and/or water footprint assessment of consumption in the area.

The water footprint accounting phase thus has 11 parameters or data points in three groups for every water use sector. This results in the data overview presented in figure 3.2.. This overview captures all data of the water footprint accounting phase.

water user sectors	Internal water footprints															
	WF_{area}				$WF_{cons, area, int}$				$V_{e,area}$				$C_{user, area}$			
	bl	grn	gry	tot	bl	grn	gry	tot	bl	Grn	gry	tot	bl	grn	gry	tot
Agriculture																
Industry																
Domestic																
Total																

water user sectors	External water footprints															
	$V_{i,area}$				$WF_{cons, area, ext}$				$V_{e,r,area}$				$C_{user,ext,area}$			
	bl	grn	gry	tot	bl	grn	gry	tot	bl	Grn	gry	tot	bl	grn	gry	tot
Agriculture																
Industry																
Domestic																
Total																

water user sectors	Internal and external water footprints combined															
	$VW_{budget,area}$				$WF_{cons, area}$				V_e				$C_{cons,area}$			
	bl	grn	gry	tot	bl	grn	gry	tot	bl	Grn	gry	tot	bl	grn	gry	tot
Agriculture																
Industry																
Domestic																
Total																

Figure 3.2. Water footprint accounting data overview for a geographical area based on the water geographic water footprint accounting scheme of figure 3.1 and the manual (Hoekstra et al., 2009). For explanation see the text. Which columns of the guideline sheet are filled in depends on the scope and goal of the water footprint assessment. The guideline sheet gives an overview of all datapoints in the water footprint accounting phase. Note that $WF_{area} = WF_{cons,area,int} + V_{e,area,;}$ $V_{i,area} = WF_{cons,,area,ext} + V_{e,r,area}$ *and* $WF_{cons,area} + V_e = VW_{budget,area}$ *(see figure 3.1)*

3.3.3. Water footprint sustainability assessment

Ideally the water footprint sustainability assessment evaluates the sustainability of all water footprints against the three pillars of sustainability (economic, social and environmental). The guideline would need to capture the three pillars of sustainability for all footprint components of all sectors. However, section 3.2.3. showed that many of the indicators for the sustainability assessment have yet to be developed, tested and established. In summary these are: global blue environmental flow requirements, the notion of green environmental water scarcity, social indicators, indicators to understand the sustainability of virtual water import and external water footprints as well as social and economic indicators for grey water footprints.

In order to be able to develop the guideline for the water footprint assessment, a couple of assumptions are made:

- It is assumed that Runoff (R) and environmental flow requirements (EFR) are known. The blue environmental water scarcity indicator can thus be calculated.
- It is assumed that green water scarcity (WS_{green}) is available as an environmental indicator
- It is assumed that economic water productivity (EWP) is the relevant economic indicator to assess the economic costs and benefits of water footprints.
- It is assumed that the energetic water productivity (caloric content of produce, CAL) is a relevant social indicator. This is of course the case for agricultural products. In the case of the industrial and domestic sectors, relevant indicators should be taken into account.

- It is assumed that the sustainability of water footprints can be measured through the calculation and summing of water footprint impact indexes
- It is assumed that indicators can be found to indicate the economic costs and social effects of the grey water footprint. The guideline therefore uses placeholders for the economic (EC) and social (SOC) indicators associated with the grey water footprint.

Based on the assumptions above and the overview and discussion of indicators in the water footprint sustainability assessment section, two sustainability assessment guideline sheets are presented. The first sheet is for sustainability assessment of the internal water footprints of an area and the second sheet for the sustainability assessment of external water footprints of the area. The reason for two different sheets is that two different sustainability assessment approaches are used for the internal and external water footprints of an area respectively, as it was explained in the previous section. As can be seen, the internal water footprint uses an absolute approach based on understanding blue and green water scarcity as well as WPL and economic and social indicators. Whereas the sustainability of external water footprints is assessed using the Water Footprint Impact Index (*WFII*).

Theoretically, the sustainability of combined internal and external water footprints can be calculated by summing the water footprint impacts indicators of the internal components and external components. As explained, the sustainability of the external water footprints can be presented through relative values of the Water Footprint Impact Index (*WFII*). The sustainability of internal water footprints is assessed by means of blue, green water scarcity (*WS*) and Water Pollution Level (*WPL*). Contrary to the external water footprint sustainability assessment, the assessment of the internal water footprint is absolute. Here the quantification presents a direct connection between a water footprint (volume) and the resulting impact which is water availability minus water footprint (volume). Summing relative and absolute values for environmental sustainability is scientifically unsound and does not provide credible sustainability indicators. As can be seen from paragraph 3.2.5, theoretically, the sustainability of water footprints can be understood as summed contributions to green, blue water scarcity and water pollutions levels. This approach needs further research and testing. Also the data for using the approach are not yet available. Therefore the sustainability of combined internal and external water footprints will not be presented in the guideline.

The second guideline sheet (figure 3.3) addresses the sustainability of the internal water footprints of an area (WF_{area}), that is, the sustainability of water consumption within the area including the water consumption for virtual water export from the area. The sustainability indicators in this guideline sheet are absolute quantifications of environmental, social and economical costs and benefits associated with the water consumption of the three sectors.

water user sectors	WF_{area}									$WF_{cons, area, int}$								
	Blue			Green			Grey			Blue			green			grey		
	WS	EWP	CAL	WS	EWP	CAL	WPL	EC	SOC	WS	EWP	CAL	WS	EWP	CAL	WPL	EC	SOC
Agriculture																		
Industry																		
Domestic																		
Total																		

water user sectors	$V_{e,area}$								
	Blue			Green			Grey		
	WS	EWP	CAL	WS	EWP	CAL	WPL	EC	SOC
Agriculture									
Industry									
Domestic									
Total									

Figure 3.3. A water footprint sustainability assessment guideline sheet expressing the water footprint sustainability indicators for the internal water footprints of the three water using sectors in a geographic area. Indicators in the guideline sheet included the environmental indicator,(environmental water scarcity, WS,) the economic indicator, economic water productivity (EWP), and the social indicator caloric content (CAL), for blue and green water footprints. For the grey water footprint, the environmental indicator is water pollution level (WPL) as well as the economic (EC) and social (SOC) placeholder indicators. Which columns of the guideline sheet are filled in depends on the scope and goal of the water footprint assessment. The guideline sheet gives an overview of all data points in the water footprint sustainability assessment phase. For further explanation, see text.

To assess the sustainability of the external water footprint components, a third guideline sheet is presented in Figure 3.4. As explained above, the guideline uses the water footprint impact index (*WFII*) to understand the environmental sustainability of the internal and external water footprints associated with an area. According to the manual (Hoekstra et al., 2009), a green, blue or grey *WFII* is based on the WF of a product, consumer or producer specified by catchment *x* on time *t* and the blue, green water scarcity (*WS*) or Water Pollution Level in catchment *x* on time *t*. Assuming that the green and blue Water Scarcity (*WS*) and Water Pollution Level (*WPL*) of catchment *x* at time *t* is known, it can be argued that WFII's can be calculated for any process water footprint (WF_{proc}) occurring in catchment *x* at time *t*. Green, blue and grey WFIIs of a process water footprint can be calculated for all process water footprints by multiplying the process water footprint respectively with the green and blue water scarcity and WPL in catchment *x* at time *t*. The manual (Hoekstra et al., 2009) states that process water footprints are the basic building block for all other water footprints. Any water footprint (WF_{any}) is made up of its underlying process water footprints *q* occurring at place *x* at times *t* as in the equation below:

$$WF_{any} = \sum_{q} WF_{proc}[q(x,t)]$$

The green, blue and grey *WFII*s of any water footprint (WF_{any}) can be calculated by summing the *WFII*s of the process water footprints that it comprises. WFIIs can thus be calculated for all water footprint components of an area if the WF specifies *x* and *t;* assuming the green and blue water scarcities and Water pollution level are known. Below the equations box 4.4 of the manual (Hoekstra et al., 2009) are presented in an adapted form.

$$WFII_{blue,WF_{any}} = \sum_x \sum_t (WF_{blue,proc}[x,t] \times WS_{blue}[x,t])$$

$$WFII_{green,WF_{any}} = \sum_x \sum_t (WF_{green,proc}[x,t] \times WS_{green}[x,t])$$

$$WFII_{grey,WF_{any}} = \sum_x \sum_t (WF_{grey,proc}[x,t] \times WPL[x,t])$$

Following the equations above, the *WFII*s for all external water footprint components of the area can be calculated. For this data are needed on the underlying process water footprints *q* occurring in a variety of catchments *x* at times *t*. And, also data are needed on the green and blue water scarcity and water pollution level in catchments *x* at times *t*. Providing these data are available, the WFIIs of the external water footprint components can be calculated. Figure 3.4 below presents the WFIIs of the external water footprint components.

guideline sheets alongside each other (figure 3.3 and figure 3.4). The combined analysis of the two filled out guideline sheets will give quantified pointers for the sustainability of water footprints of the area. This in turn provides the context and foundation for the formulation of water footprint response measures. There are several caveats in the sustainability assessment guideline:

- Social indicators are captured by place holders only and need further elaboration
- The sustainability assessment for the internal water footprint of an area is absolute whereas the sustainability assessment of the external water footprint of an area is relative.
- No tested approach exists for executing a sustainability assessment of the internal and external water footprint combined
- The applicability of the *WFII* approach for the internal water footprint of an area has yet to be assessed

Water use sectors	**External water footprints**															
	$WF_{cons,\ area,\ ext}$				$V_{i,area}$				$V_{e,r,area}$				V_e			
	blue	green	grey	Total	blue	Green	grey	total	blue	green	grey	total	blue	green	grey	total
	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII
Agriculture																
Industry																
Domestic																
Total																

Figure 3.4. The second water footprint sustainability assessment guideline sheet expressing the water footprint impact indexes, external water footprints. On the horizontal axes, for all water footprints, the green, blue and grey components and total plus associated water footprint impact indexes (WFII) are presented. On the vertical axis, the WFII can be presented for separate processes, products, water use sectors: x, y, z, etc, depending on the scope and goal of the assessment. (Hoekstra et al., 2009)

There are restrictions associated with the WFII. The WFII is currently not displaying any information on social and environmental benefits and costs. Also, the WFII is the value of a water footprint that is weighed according to the environmental water scarcity and/or pollution level of the area where the water footprint occurs. And thus it gives only information on the relative contribution of water footprints to environmental impacts (Hoekstra et al., 2009). Because the WFII is relative, underlying variables and connections to the environmental reality might be obscured.

To summarise, to assess the sustainability of water footprints of an area, the approach is to use the two

3.3.5. Water footprint response formulation

The overarching goal of the water footprint response can generally be stated to be increasing the sustainability of water footprints by promoting efficient water use while safeguarding the environment and achieving maximum economic and social benefits. In order to achieve this goal, the key sustainability issues that are generated in the water footprint sustainability assessment need to be translated in water footprint response measures. As we will see in this section there are three steps in this process:

1. definition of quantitative water footprint response objectives,
2. definition and evaluation of quantitative water footprint response strategies
3. design of policy and practical response measures

These three steps will be elaborated below.

WATER FOOTPRINT RESPONSE OBJECTIVES

The sustainability issues from the water footprint sustainability assessment phase serve as the specific objectives that should be achieved by the water footprint response. They are the water footprint response objectives.
In order to enable measurement of progress towards the response objectives, the sustainability issues need quantification. Quantification is done by translating the sustainability issues into volumetric water footprint reduction targets associated with water using sectors in time and space. The water footprint reduction targets are the quantification of the water footprint response objectives. The response objective also specifies the water footprint component it is aimed at reducing. For example, assume that the blue environmental water scarcity is too high in a certain area at a certain time. The associated water footprint response objective is then aimed at reducing blue water footprint within the area ($WF_{area,blue}$) by X m^3/yr. The sector focus could be to reduce the blue water footprint of agriculture within the area. The total water footprint response objective then becomes: reducing the $WF_{area,blue}$ of agriculture by X cubic meter a year, or -X m^3/yr.

WATER FOOTPRINT RESPONSE STRATEGIES

The next step in the response formulation is to define strategies to achieve the response objective i.e. the reduction of a specific water footprint. Following the manual, there are a limited number of strategies (Hoekstra et al., 2009):

1. absolute reduction of the water footprint by
   - avoiding the water footprint
     increasing the efficiency of the water
   - consumption
2. substitution of a water footprint by another water footprint by
   - substituting blue water footprints by green water footprints and vice versa
   - substituting internal water footprints by external water footprints and vice versa
3. compensating a water footprint by a water offset (see 2.5.4 for more information)

Water footprint reduction strategies can be evaluated on their effectiveness to achieve the water footprint response objective through running scenarios. The scenarios are built by adapting the sheets for the footprint accounting (Figure 3.2) and sustainability assessment (figures 3.3 and 3.4).

Following the earlier example, the objective could be to reduce the blue water footprint within the area of agriculture by -X m^3/yr. In Figure 3.5, this objective is shown as the red box in the water footprint accounting sheet.

The strategy chosen in the example is to substitute the blue water footprint reduction X by a virtual water import of Y m^3/yr. The virtual water import thus increases with +Y m^3/yr. X and Y are not necessarily equal. The reason is that not the water footprint X itself is substituted but the volume of agriculture production (tonnes) associated with the water footprint X. This volume of produce is imported from another area at another time with other climatic conditions. These conditions determine Y and will be most likely different from X, lower or higher depending on the climate. The strategy +Y is shown as the green box in Figure 3.5.

Water user sectors	Internal water footprints															
	WF_{area}				$WF_{cons,\ area,\ int}$				$V_{e,area}$				$C_{user,\ area}$			
	bl	grn	gry	tot	Bl	grn	gry	tot	bl	grn	gry	tot	bl	grn	gry	
Agriculture	-X															
Industry																
Domestic																
Total																

water user sectors	External water footprints															
	$V_{i,area}$				$WF_{cons,\ area,\ ext}$				$V_{e,r,area}$				$C_{user,ext,area}$			
	bl	grn	gry	tot	Bl	grn	gry	tot	bl	grn	gry	tot	bl	grn	gry	tot
Agriculture	+Y															
Industry																
Domestic																
Total																

water user sectors	Internal and external water footprints combined															
	$WF_{cons,\ area}$				V_e				$WF_{budget,area}$				$C_{user,cons,area}$			
	bl	grn	gry	tot	Bl	grn	gry	tot	bl	grn	gry	tot	bl	grn	gry	tot
Agriculture																
Industry																
Domestic																
Total																

Figure 3.5 Using the water accounting sheet (figure 3.2) to display a water footprint reduction scenario. The objective (water footprint reduction, -X m3/yr) is shown in red, the strategy (water footprint substitution, +Y m3/yr) is shown in green.

Water user sectors	WF_{area}									$WF_{cons,\ area,\ int}$								
	blue			grn			grey			blue			grn			grey		
	WS	WEP	CAL	WS	WEP	CAL	WPL	EC	SOC	WS	WEP	CAL	WS	WEP	CAL	WPL	EC	SOC
Agriculture																		
Industry																		
Domestic																		
Total																		

Water user sectors	$V_{e,area}$								
	blue			grn			grey		
	WS	WEP	CAL	WS	WEP	CAL	WPL	EC	SOC
Agriculture									
Industry									
Domestic									
Total									

Figure 3.6. The recalculated water footprint assessment sheet for internal water footprints alone (Figure 3.3) showing the sustainability outcomes of the water footprint reduction strategy of Figure 3.5 in the yellow cells (applied at the watershed where Y is coming from).

Water user sectors	External water footprints															
	$WF_{cons,\ area,\ ext}$				$V_{i,area}$				$V_{e,r,area}$				V_e			
	blue	green	grey	total	blue	green	grey	total	blue	green	grey	total	blue	green	grey	Total
	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII	WFII
Agriculture																
Industry																
Domestic																
Total																

Figure 3.7. The recalculated water footprint assessment sheet for the external water footprints (Figure 3.4) showing the sustainability outcomes of the water footprint reduction strategy of Figure 3.5 in the yellow cells.

Similarly, the strategy can be evaluated on water footprint sustainability outcomes by recalculating the water footprint sustainability assessment sheet on the basis of the water footprint reduction scenario of Figure 3.5. Figures 3.6 and 3.7 show where sustainability outcomes can be expected in the two sustainability assessment guideline sheets of figure 3.3 and 3.4 as yellow highlighted cells. As this is a hypothetical, non quantitative example no values are given in the cells.

The sustainability outcomes of the strategy, in terms of WS_{blue}, *EWP*, *CAL* and $WFII_{Vi}$, can be evaluated on trade offs in terms of environmental, social and economic benefits and costs. If the trade offs are not satisfactory, other strategies can be evaluated through a similar scenario exercise. The process is iterative and stops when the best available water footprint response strategy is identified. The final outcome of the process is a best fit response strategy to inform the design of policy and practical response measures specifying geographic scale and sectors. This last step is a more qualitative and political process. The previous chapter argues that water footprint responses cannot yet be assessed in terms of quantitative reductions in water footprints. This is due to the fact that the exact water footprint reduction associated with a specific response is not systematically available.

STEPS IN WATER FOOTPRINT RESPONSE FORMULATION

The fairly restricted example of the previous paragraph shows that the water footprint response formulation process consists of three steps:

1. definition of quantitative water footprint response objectives,
2. definition and evaluation of quantitative water footprint response strategies,
3. design of policy and practical response measures.

Step 1 and step 2 can be based on quantitative information. The quantification of the policy and practical measures of step 3 in terms of water footprint reductions needs elaboration. Currently this step is a more qualitative and political process.

3.5. Conclusions and discussion

Part 3 presents a practical guideline to execute a water footprint assessment of a geographical area following the water footprint assessment procedure outlined in the manual.
The guideline provides new additions to the manual in terms of data collection and analysis for doing a water footprint assessment of a geographical area. These are:

- structured data sheets for the water footprint accounting phase, water footprint assessment phase and water footprint response formulation phase
- a proposal to use contribution factors to understand the relative contribution of water users to the overall water footprints in geographic areas

- a proposal to expand the use of the water footprint impact indexes as sustainability indicators for relative comparison of the "water performance" of multiple watersheds.
- a proposal for a systematic three-step approach to the water footprint response formulation phase
- a proposal for a quantified scenario analysis approach in the water footprint formulation phase to evaluate the effectiveness of different water footprint response strategies

3.6. Research and development

Part 3 shows a number of research and development topics. There is a need for

- More systematic research on and testing of relevant economic and social sustainability indicators is needed. Currently only a restricted set of indicators is presented in various studies and this report. Also, the sustainability indicators used to assess the sustainability of virtual water imports need to be enhanced.
- Development of deeper understanding on the quantification of water footprint policy and practical measures from Part 2 of this report is severely needed to evaluate responses beyond the water footprint reductions.
- Further developing the guideline:
    - It does not capture the sustainability assessment of internal and external water footprints combined
    - It does not capture the social and economical impacts of virtual water imports.
    - It cannot capture multiple time periods with higher level temporal resolution, the water footprint assessment tool is mechanism to push this agenda
    - The response strategy scenario evaluation needs to be completed so that all possible strategies can be tested
    - The contribution ratios need testing and elaboration in terms of use as indicators to report on water sustainability of water users
- Elaborating the green water availability and green water scarcity components in the water footprint assessment in terms of clarity of the concepts and feasibility with respect to data requirements.
- Testing and refining the guideline on the basis of application in diverse geographical units comprising catchments, districts and cities.

OVERALL CONCLUSIONS AND DISCUSSION

This report presents the first comprehensive overview and analysis of applications of the water footprint assessment in different geographical areas. It also provides an overview of different responses and measures to enhance the sustainability of water footprints and finally proposes a practical guideline for water footprint assessment of a geographical area. The findings in this report provide guidance for further development of the water footprint manual on the use and application of the water footprint in geographical areas to inform decision making on water resources management.

All the studies presented in this report pick up key pieces of the Water footprint assessment of a geographical area. However, none of the studies present a full scale water footprint assessment. There are different reasons for this. A first and obvious reason is that the studies were done before the publication of the Water footprint assessment framework (Hoekstra et al., 2009). Secondly, a big challenge that is present in all cases, is the fact that data requirements can be substantial and that if data sets exist these are often not fully compatible. A third reason is that while sustainability is central to many of the studies, apparently, translating the sustainability concept into a comprehensive analytical framework for water management appears to be a daunting task that is often beyond the studies. While the above may sound as criticism, this is not the intention; the studies were conducted with a specific goal (often scientific) in mind and therefore did not intend to do full water footprint assessments. Also and to their full merit, the studies did provide key pieces for a more unified guideline that is now available for further testing in different contexts.

The report provides a long list of policy and practical measures at different geographical scales. However, analysing, quantifying and prioritising measures on their benefits for water footprint reduction and water footprint sustainability has not been possible within the scope of the study. There are three main reasons for this, 1. a systematic analytical guideline for doing so did not exist until now, and 2. now that a guideline exists it is clear that none of the studies has enough data to populate the guideline completely to enable a sensible analysis of the list of measures, and 3. a global prioritisation of most effective and efficient measures might fail because of the localised nature of water related issues and non water aspects that influence the water footprint reduction outcomes of policy and practical measures.

Key areas of research and development have been identified, none of which are really new. Studies required should address: water footprint sustainability assessment indicators, environmental flow requirements, green water availability and scarcity. In this sense the report has reinforced the research and development agenda in the field of water footprint. Priority topics for R&D are:

- Research and development of water availability databases with 'rule of thumb' environmental flows requirements
- Research on social and economical sustainability indicators
- Research to improve the generic nature of the sustainability assessment guideline building on contributions of water footprints to sustainability indicators
- Research on the analysis of policy and practical measures in terms of water footprint reduction outcomes for scenario analysis
- Further research on green water footprint sustainability

The report is highlighting the prototype nature of the guideline. Concretely this means that the guideline is not finished, it needs further work:

- It needs testing in different geographies, preferably in close collaboration with partners and the WFN that has developed the guideline and will continue to do so. There are several localities that are available for testing: Lake Naivasha, Kenya, Sao Paulo, Brazil, several locations in Chile (Huasco and Rapel rivers), several locations in China among which Beijing municipality, several locations in Spain, Peru, India, Sri Lanka, Vietnam, Tunisia and the Nile Basin. All of these localities have partners of the Water Footprint Network (WFN) present that are interested to collaborate.
- It needs theoretical elaboration especially on bringing in the sustainability of virtual water trade and external water footprints and internal water footprints combined, grey water footprint sustainability, green water footprints and green water scarcity.
- It needs to be elaborated and tested to run response scenarios based on the long list of policy and practical measures in Part 2 of this report.

- It needs to inform and get informed by the Water Footprint Database and Water Footprint Assessment Tool projects of the WFN.
- It needs to be tested in the contexts of business water footprint assessment and other business water accounting systems.
- It needs to be tested on its effectiveness in the social and institutional setting of water management decision making, meaning, testing its functionality in guiding discussions and decisions of policy makers, water managers and stakeholders on water and related policy sectors.

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Annex I CASE STUDIES ON THE GEOGRAPHICAL APPLICATIONS OF THE WATER FOOTPRINT

1. GEOGRAPHICAL UNIT: **RIVER BASIN**

1. Water Footprint Analysis for the Guadiana River Basin, Spain; 2008

Author organisations	University of Twente (NL), University of Madrid (SP)
Short description and objectives	An economic and hydrological analysis of the virtual water trade and water footprint of the semiarid Guadiana river basin, considering both green and blue water consumption in the different economic sectors, is done. The goal is to provide a better knowledge of the WF and VW 'trade' in the river basin in order to facilitate a transparent and multidisciplinary framework for informing and optimising water policy decisions.
Methodology / indicators used	- Preliminary analysis and data collection: geographic, social, climatic, agricultural, hydrological, economical, trade and policy information. - Identification of consumptive water uses per type of water (green and blue water) and economical sector. - River basin divided into 4 separate regions for the analysis, since within the same basin each region presents different conditions/background. - Identification of the most representative crops per region based on the number of hectares, economic productivity and water consumption. - Calculation of the virtual water content of crops, agricultural economic productivity and economic blue water productivity, per crop, per region. - Evaluation of agricultural and virtual water trade per region.
Remarks	- Agriculture is the main water-consumptive activity in the basin. - Three different rainfall years evaluated. - Blue water differentiated into ground and surface water.
Innovative contribution	Consideration of hydrologic aspects together with economic and ecological aspects.
Conclusions	- The different regions of the Guadiana basin have different trade strategies. The Upper Guadiana basin is a net exporter, barely importing any food commodity. The Lower Guadiana regions import low-value, high water-consuming crops, while exporting high-value, low virtual-water content crops. This reduces the demand on local water resources which can be used to provide ecological services and other more profitable uses. These data show that the problem in the Guadiana basin is not water scarcity but the use of water for low value crops. - Economic water productivity not only depends on the climatic conditions of each region and particularly on the yields, but also on the efficiency of the water use.
(Potential) applications to policy	Comparison between results from this study and existing Guadiana river basin water management plans. In the context of the Especial Plan of the Upper Guadiana, Offer of Public Purchase (OPA) has been established to address serious problems of overexploitation in the basin. In theory this basin will grant less rights than it has purchased, allocating the difference to wetlands and to increasing the piezometric levels of the aquifers.
Recommendations / limitations	- Additional aspects should be taken into consideration such as crop diversification, labour or other environmental, social, economic and agronomic aspects, to avoid simplified conclusions. - Include nutritional value information of crops in future studies.
Lacking	Grey water analysis
Sources	Aldaya, M.M. and Llamas, M.R. (2008). Water footprint analysis for the Guadiana river basin. Value of Water Research Report Series. No. 35. UNESCO-IHE: The Netherlands.

1.2. Water demand management: A case study of the Heihe river basin in China; 2005.

Author organisations	**UNESCO-IHE, Delft University of Technology**
Short description and objectives	The study investigates the water supply and demand situation in the Heihe River Basin, China, and formulates a demand oriented water management approach in the irrigated agricultural sector in response to the increasing water shortage due to population growth and local economic development. The increasing water scarcity in the basin and large water consumption in agriculture provoke the question whether they should produce water-demanding products locally or if they can import water-intensive products from water rich regions. For this purpose, a virtual water trade analysis is done.
Methodology / indicators used	- Data collection on water supply and availability, current and future demand for water resources, policies, strategies, pricing and key institutions. - Virtual water trade analysis: calculation of the virtual water content (blue and green) of crops and livestock with regional data. - Calculation of the water productivity (US $/m^3). - Evaluation of agricultural and virtual water trade per region.
Remarks	Irrigated agriculture uses 80% of the available fresh water. Data used: 2001-2002.
Innovative contribution	Virtual water trade analysis at a river basin level, water productivity.
Conclusions	- The present water pricing system gives the impression that the existing water charge does not encourage efficient use of water. Together with the virtual water trade analysis, it is indicated that the irrigation districts as the biggest water user should be put into strict demand control, the agricultural sector should be tuned to products with higher water use efficiency. 35% of annual blue water, and 44% of annual green water is used for export in virtual water form. In such an arid area, export of such a high amount of virtual water should include efforts to maximize water productivity. - The Heihe River Basin should better focus on the products requiring less water compared to the revenue from the production. This implies importing water intensive products, and replacing them by less water-demanding products with higher revenues. The export of livestock products, which use relatively more green water, cannot be replaced by export of crops that depend on blue water. However, milk, chicken and pork could partly replace beef and mutton production. Virtual water trade can be a useful instrument to mitigate water scarcity in the basin. Producing the products with high water productivity such as cotton, grape and date, and reducing the water demanding products with less revenue are good options to improve efficiency of water consumption. - The water scarcity in the Heihe River Basin is not only caused by the physical condition, but is also the result of lack of integrated river basin management.
(Potential) applications to policy	Virtual water trade can be a useful instrument to mitigate water scarcity in the basin. Reducing the export of low value virtual water and maximizing high value virtual water is necessary in such an arid area. Producing the products with high water productivity such as cotton, grape and date, and reducing the water demanding products with less revenue are good options to improve efficiency of water consumption. With increasing water scarcity, the need for financial sustainability and declining financial resources available for irrigation and water resource development, reform of water pricing is essential in the region.
Recommendations / limitations	
Lacking	Grey water analysis
Sources	Chen, Y., et. al. Water demand management: A case study of the Heihe river basin in China. Physics and Chemistry of the Earth 30 (2005). 408 – 419.

1.3. Real and virtual water and water footprints: a comparison between the lower Fraser valley and the Okanagan basin; 2007.

Author organisations	University of British Columbia (CA)
Short description and objectives	The overall goal of the study is to assess the different uses of water in two basins, the Okanagan Basin (OK) and the Lower Fraser Valley (LFV), Canada. The Okanagan basin is the driest watershed and the Lower Fraser Valley is one of the wettest watersheds in the country. Food production is widespread in both basins, and both areas are experiencing some of the most rapid population growth rates in the country.
Methodology / indicators used	- Identification of major crops and crop water requirements in both basins (average 1995-2005). - Calculation of water footprints of crops and livestock in both basins, for 1991 and 2001. - Comparison of VWC of crops to Canadian and global statistics - Economic assessment and comparison with water use for some crops. - Water used (and irrigation requirements) by golf courses in the Okanagan basin, for the 1995-2005 average golf seasons and for 2006 golf season (dry year). - Analysis of the water mass balance in the Okanagan Lake: water demands and comparison in water uses.
Remarks	Mean monthly evapotranspirations calculated from 10 years (1995-2005), using climatic data of the nearest climatic stations, which were used to calculate crop Water Footprints. Production and yields data for 1991 and 2001 agricultural census.
Innovative contribution	First time in Canada that a detailed comparison on water needs for different food produced in two river basins has been made. The study provides key information for the determination of the water balance for the Okanagan Basin.
Conclusions	The most water demanding crops were hay fodder in the Lower Fraser Valley, and alfalfa and apples in the Okanagan Basin. Apples together with alfalfa, and hay fodder make up 81% of crop water use in the Okanagan. The major difference between the regions is the importance of berry versus fruit crops. The four berry crops (strawberries, blueberries, raspberries and cranberries) in the Lower Fraser Valley have a value of $133 million and use 32 million m^3 of water per year. In contrast the four major fruit crops in the Okanagan (apples, peaches, cherries and grapes) have a value of $81 million but use 63 million m^3 of water per year, more than double of that used by the four major berry crops in the Lower Fraser. The average golf courses irrigation requirement from 1995-2005 for the entire Okanagan Basin averaged approximately 2 million m3 of water per year. This is much lower than the 5 million m3 total calculated for the 2006 golf season (a dry year in the Okanagan). The Blue water storage was estimated at 598 Mm3/yr (reservoir storage and available lake storage) and the water demand consisting of domestic, golf, crop and 26 livestock requirements were estimated to be 546 Mm3/yr. This does not include groundwater and reservoir storage in the lowest part of the basin, and the industrial and commercial use for which no data was yet available. It also does not include the green water component nor water for environmental services. Assuming that these are compensating differences, approximately 90% of the blue water is currently being used.
(Potential) applications to policy	This information will provide a basis for the development of a water conservation strategy that is now being initiated by the Okanagan Basin Water Board. Decision makers can now assess in quantitative terms what activities are most water intensive and what the best trade-offs are in terms of water conservation. No previous study has examined the overall water use for the different crops and livestock in the two basins and the results provide decision makers with information related to water use efficiency for different foods produced in each basin. It also forms the basis for determining trade-offs in water requirements for growing different food, which then tells water managers how much water savings or how much more water will be required by changes in agricultural land use and management.

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Author organisations	University of British Columbia (CA)
Recommendations / limitations	- The data cover the 2001 situation and needs to be updated to 2006. - Very limited information was available on the amount of water needed to process the crop into a product. - No food export and import data was available at the regional level. - Very limited economic information was included (except for fruit and berry production) and this would further enhance trade of analysis. - Additional information needs to be collected for the surface and groundwater supply storage capacity and the water demand for industrial and commercial use. This will then allow for a more refined analysis of a water balance.
Lacking	- The water mass balance is done only for blue water. No distinction between green and blue components of the agricultural WF (However the green component is estimated to be small because there is only little rainfall during the growing season). - Virtual water flows - Grey water analysis
Sources	Schreier, H., Lavkulich, L., Brown, S. (2007) Real and virtual water and water footprints: A comparison between the lower Fraser Valley and the Okanagan Basin. Schendel, E., MacDonald, J., Schreier, H., Lavkulich, L.M. (2007) Virtual water: A framework for comparative regional resource assessment. Journal of Environmental Assessment Policy and Management. Vol 9, No.3, pp. 341 - 355. Brown, S., Schreier, H., Lavkulich, L.M. (2009) Incorporating virtual water into water management: A British Columbia example. Water Resource Management. Vol 23. DOI 10.1007/s11269-009-9403-8. pp. 2681 – 2696.

2.1. Incorporating the Water Footprint and Virtual Water into Policy: Reflections from the Mancha Occidental Region, Spain; 2008

Author organisations	**University of Twente (NL), Complutense University of Madrid (SP)**
Short description and objectives	This study provides a joint economic and hydrological perspective on virtual water 'trade' and the water footprint of the Mancha Occidental region, Spain, exploring the connections between water use, food production and environmental management.
Methodology / indicators used	Calculation of the virtual water content of the crops, the agricultural economic productivity, economic water productivity and the virtual water 'trade' under different climatic conditions.
Characteristics / remarks	- Agriculture is the main water-consumptive activity in the region (95%). - Blue water differentiated into ground and surface water. - Three different rainfall years evaluated. - A stark example of inappropriate groundwater management.
Innovative contribution	Reflections about the benefits and limitations of the methodology.
Conclusions	This study supports the new policies in the Mancha region, which point at either a change in cropping patterns or a drastic reduction of the irrigated surface in the region. The results of this study support this paradigm shift by showing to what extent there is an imbalance between the region's water and land uses and its natural resources. However, it is also recognized that several obstacles challenge their implementation, some of which are found at the regional and the farm scales. Other environmental, socio-economic and agronomic factors may pose practical challenges.
(Potential) applications to policy	The current crop structure is the result of farmers' pursuit of cost effectiveness. Low economic productivity irrigated cereals are widespread during the study period, which is partly due to the EU Common Agricultural Policy (CAP) subsidies. The 1992 CAP reform included direct payments per hectare, whose amount depended on the average yields of each region. Since irrigated cereals have higher yields than the same crops under rainfed regimes, farmers with irrigated land received larger per hectare payments and had clear incentives to irrigate their crops. This scheme induced irrigation and intensified farming most acutely in arid and semi-arid regions. Therefore, it makes short-term economic sense for the farmers to use water as they do for cereals, since they are subsidised and provide a relatively safe profit. In this study, the water footprint represents a tool to inform water policy. By allowing a comparison between the existing uses and the available resources the water footprint provides useful knowledge as to whether a region is using its water effectively. This tool can also be useful to inform a water rights system.
Recommendations / limitations	- Uncertainties in the results due to insufficient data, several assumptions done. - Need to include Environmental Water Requirements in the analysis, although there is very limited information on this topic. - Need to further explore whether exported products are more related to water depletion or pollution in the producing region. - The methodology may need complementary tools to balance factors such as risk diversification and labour, as well as other environmental, social, economic and agronomic considerations, particularly at the user scale.
Lacking	Grey water analysis
Sources	Aldaya, M.M., Martínez-Santos, P. and Llamas, M.R. (2009) Incorporating the water footprint and virtual water into policy: reflections from the Mancha Occidental region, Spain. *Water Resources Management.* DOI 10.1007/s11269-009-9480-8.

2.2. Incorporating the Water Footprint and Environmental Water Requirements into Policy: Reflections from Doñana National Park (Spain); 2009

Author organisations	University of Twente (NL), University of Seville, Complutense University of Madrid (SP)
Short description and objectives	This report analyses the water footprint of the Doñana National Park and presents the first attempt to quantify the environmental water requirements from the ecosystem perspective. The Doñana National Park, located at the mouth of the Guadalquivir river in south-western Spain, is one of the largest and most important remaining wetlands in Europe. The final objective of the study is to improve the practice of water resources planning and management, and the condition of ecosystems and associated livelihoods through the application of the water footprint analysis. This report also aims to illustrate the role of the environment as a legitimate 'water user' in water resources assessments. For this purpose the present study analyses the water footprint of household, industry and agriculture from the production perspective. This is compared with the water used by the environment differentiating between the blue and green components in the Doñana region.
Methodology / indicators used	- Determination of environmental water requirements are estimated in the region. - Water footprints of agriculture: green, blue (surface and groundwater) and grey water components of the most representative crops. - Estimation of water used in household and industries (from the perspective of water supplies) – blue water component (surface and groundwater). - Estimation of the water footprints of natural forests. - Economic water productivities for main crops - Assessment of water uses in the Doñana region, current trends, problems and initiatives. - Estimation of total water availabilities and comparison with environmental flow requirements and actual water uses.
Remarks	- Grey water from agriculture included in the analysis - Calculations done for an average rainfall (2001)
Innovative contribution	It is the first time that the environmental water requirements are analysed in the water footprint context. A significant innovation of this work is to emphasize the imperative challenge of considering the environmental water requirements. The application of an integrated approach using the water footprint and environmental water requirement analysis, could improve the practice of water resources planning and management, and the condition of ecosystems and associated livelihoods.
Conclusions	- Currently the main green and blue water user in the Doñana Park is the environment, using about 61% of total water consumption in an average rainfall year. Agriculture is the second main water user amounting to about 39% of total water consumption, whereas urban water supply and industry use around 1%. Consumptive water uses for all except for industry and domestic, which is expresses as water withdrawal). - The total blue water available in the region amounts to 443 Hm^3 for an average rainfall year. If the environmental water requirements (or water needed to maintain the wetlands) were subtracted to this figure, 200 Hm^3 according to WWF (2009a) estimation using the ELOHA model (including marshes, streams and aquifer), the total water available for human use in the region would be 243 Hm^3. The current agricultural blue water footprint alone adds up to 282 Hm^3 whilst the urban and industrial uses to 7 Hm^3. The environmental blue water requirements thus seem to be violated in the Doñana region. - The total current environmental blue water use in the Doñana National and Natural parks amount to about 154 Hm^3. The environmental green water requirements of forests add up to about 442 Hm^3 - The cultivation of strawberry brings some serious environmental problems, but it has a vital economical significance for the region.

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Author organisations	University of Twente (NL), University of Seville, Complutense University of Madrid (SP)
(Potential) applications to policy	Integrated water allocation, planning and management is needed in the Doñana region, considering the environmental water requirements together with the blue (surface and ground), green and grey water footprints, to achieve a more compatible agricultural production with the protection of ecosystems. This could be done through a Water Management Council, assisted by a Scientific Council for Water, which would receive recommendations from legally responsible agencies.
Recommendations / limitations	- As a first approximation an average rainfall year is analysed. In further studies, however, it would be interesting to account for temporal variability. - This analysis is a first approximation since data on the environmental water needs are limited. If the evapotranspiration by scrub-lands had been taken into account, these figures would have probably been higher.
Lacking	
Sources	Aldaya, M.M., Martínez-Santos, P. and Llamas, M.R. (2009) Incorporating the water footprint and virtual water into policy: reflections from the Mancha Occidental region, Spain. Water Resources Management. DOI 10.1007/s11269-009-9480-8.

3. GEOGRAPHICAL UNIT: **NATIONAL**

3.1. The Water Footprint of Spain; 2008

Author organisations	**University of Madrid (SP), University of Twente (NL)**
Short description and objectives	Water Footprint and Virtual Water trade were analysed for the most arid country in Europe, Spain, from a hydrological, ecological and economic perspective, aiming to facilitate an efficient allocation of water resources. This analysis can provide a transparent and multidisciplinary framework for informing and optimising water policy decisions, contributing at the same time to the implementation of the EU Water Framework Directive. The following questions are addressed: - What is the virtual water and water footprint of Spain? Are the green and blue water (surface and groundwater) components different and significant? - What are the economic implications for water allocation in Spain in light of these new evaluations? - Should we revisit the paradigm of water scarcity in Spain and in most semiarid countries? - What do the economic evaluations of virtual water 'trade' and footprint imply in terms of the practical applications of these concepts? - What lessons can be learned from a detailed analysis at a river basin level (case of the Guadiana River)? This study also helps explaining the roots of regional water conflicts, and the role of water markets, through a detailed geographical analysis of water productivity changes across provinces and throughout the study period.
Methodology / indicators used	- Overview of Spain's different sectors and their water use. - Spain's Water Footprint calculation: total water use in the country + virtual water import – virtual water export. - Water Footprint of Agriculture - Comparison of the economic productivity of irrigated and rain-fed agriculture, calculation of the blue water productivity and analysis of the virtual water trade in and out Spain.
Remarks	- Irrigated agriculture uses 80% of the available fresh water. - Differentiation between blue surface and ground water.
Innovative contribution	- Incorporation to policy. - Changing the water security and food security concepts, by showing the intimate link between water resources management and the structure of the global economy. - Traditionally, the management of water resources has focused on a supply-side approach. Regular supplies of water have been ensured using a combination of reservoirs, inter-basin transfers and increasing abstraction of both surface water and groundwater, with no incentive to limit water use in any sector other than command and control, and leaving the major driving forces of use unchanged. The present analysis focuses on a 'demand-led' integrated approach to water resource management, assessing the potential for using water more efficiently while considering the global dimension of water management.
Conclusions	- At a national scale, Spain exports high economic value and low virtual water content crops, such as citrus fruits, vegetables or olive oil, while it imports virtual water intensive and low-economic value crops, such as cereals. Nevertheless, water scarcity in Spain is mainly due to the inefficient allocation of water resources and mismanagement in the agricultural sector at a regional level, such as the use of large amounts of blue water in virtual water intensive but low economic value crops. - There seems to be enough water to satisfy the Spanish agricultural sector needs on the whole, but efficient allocation and management of water resources are necessary conditions.

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Author organisations	University of Madrid (SP), University of Twente (NL)
(Potential) applications to policy	This analysis provides interpretative bases for some of the regional water conflicts in Spain (which were sparked by the proposal of the National Hydrological Plan in 2001 and which have not yet been settled) and sheds light on the water market forces behind the inter-basin water exchanges that have taken place in recent years. Spain is the first country that has included the water footprint analysis into governmental policy making in the context of the EU Water Framework Directive. In September 2008, the Spanish Water Directorate General, approved a regulation that includes the analysis of the water footprint of the different socio-economic sectors as a technical criterion for the development of the River Basin Management Plans.
Recommendations / limitations	Several assumptions are done due to limitations in data availability.
Lacking	Grey water analysis
Sources	Garrido, A., Llamas, M.R., Varela-Ortega, C., Novo, P., Rodríguez, R., Aldaya, M. (2009). Water Footprint and virtual water trade of Spain: policy implications. In press. Aldaya, M.M., Garrido, A., Llamas, M.R., Varela-Ortega, C., Novo, P. And Rodríguez, R. (2009) Water footprint and virtual water trade in Spain. In Garrido and Llamas (Eds.) Water Policy in Spain. Taylor & Francis, London. 49-59 pp

3.2. Food consumption patterns and their effect on water requirement in China; 2008

Author organisations	**Eawag (CH), UNESCO-IHE (NL), Delft University of Technology, University of Beijing (China)**
Short description and objectives	The aim of this paper is to quantify how food consumption patterns influence water requirements in an aggregated way for China.
Methodology / indicators used	- Population food requirements estimated at three different nutrition levels. - Calculation of the VWC of main crops and livestock and its energy – water productivity (energy produced by one unit of water). - Historical per capita water requirement for food and energy intake. - Comparison with other countries / regions. - Total Water Requirement evaluated for three scenarios; representing low, medium, and high levels of modernization. - Discussion on water management from the perspective of three water sources: blue, green and virtual water.
Remarks	Virtual water import in China is minimal, due to a food self-sufficiency policy.
Innovative contribution	- Energy-water productivity indicator as related to food consumption patterns. - Long term Water Footprint trends analysed.
Conclusions	- The effect of the food consumption patterns on China's water resources is substantial both in the recent past and in the near future. Per capita water requirement for food (CWRF) has increased about 3.5 times between 1961 and 2003, largely due to an increase in the consumption of animal products. Although steadily increasing, the CWRF of China is still much lower than that of many developed countries. When analysing the management of three water sources (blue, green and virtual) at a national level, it is clear that changing food consumption patterns will drastically affect the partitioning between green and blue water and influence the virtual water trade worldwide, since China will probably need to strengthen "green water" management and to take advantage of "virtual water" import to meet the additional total water requirement for food. - From 1985 to 1997, the CWRF increased much faster than total energy intake. The main reason for the faster growth of CWRF was the increase in the consumption of food items with low energy water productivity (animal products) and less consumption of high energy water productivity items (starchy roots). - The scenario analysis indicates that future total water requirement for food (TWRF) will likely continue to increase in the next three decades. Amongst the options, two seem feasible to meet the additional water required for food consumption, namely effectively rainfall management and increased virtual water imports. Other important ways of decreasing VWC and hence decreasing TWRF could include crop yield improvement through agricultural research and formulation of appropriate agricultural policies.
(Potential) applications to policy	Agricultural research and formulation of appropriate agricultural policies in China are particularly important given China's continued significant investment in agricultural technology research in the past decades, the food self-sufficiency policy, and the increasing emphasis on reducing the development gap between rural and urban areas, which leads to agricultural policy reform.
Recommendations / limitations	A more detailed region analysis is useful to compare water requirement with local water resources. However this kind of analysis is limited by data availability. Regional consumption and VWC data for detailed food items are generally lacking.
Lacking	Grey water analysis, Water productivity analysis
Sources	Liu, J. and Savenije, H.H.G. (2008) Food consumption patterns and their effect on water requirement in China, *Hydrology and Earth System Sciences* 12(3): 887-898.

3.3. Virtual versus real water transfers within China; 2006

Author organisations	**China Institute of Water Resources and Hydropower Research, UNESCO-IHE, University of Twente**
Short description and objectives	North China is suffering from water shortage and relies on water transfer from the south to relieve the water crisis. However, at the same time, north China, as China's breadbasket, annually exports substantial volumes of water-intensive products to south China. This creates a paradox in which huge volumes of water are being transferred from the water-rich south to the water-poor north while substantial volumes of food are being transferred from the food-sufficient north to the food-deficit south. The aim of this paper is to quantitatively assess the virtual water flows between the regions in China and to put them in the context of water availability per region
Methodology / indicators used	- Estimation of virtual water contents of crops and livestock per province - Estimation of virtual water flows within China. - Analysis of the motives that generated virtual and real water transfers, and regions with food deficit and surplus. - Calculation of the regional water footprints per capita (differentiation between ground, surface and green water). Top-down approach. - Calculation of the water self sufficiency index.
Remarks	- The focus of this study is agriculture - Analysis for 1999, a normal hydrological year for China and good in terms of harvest.
Innovative contribution	The investigation and analysis of real versus virtual water transfers in China has not yet reached further attention than rough estimation and qualitative description. This study quantifies and critically analyses the water transfers.
Conclusions	One interesting finding is that the higher the per capita water availability in a sub-region, the larger the volume of virtual water import. Huang-huai-hai, for instance, has a population of 310 million and a water availability of 550 m^3 per person per year, which is even less than in the Middle East and north Africa. Nevertheless, virtual water export from this region, which is regarded as one of the most water-scarce territories in the world, is quite substantial. Just from the perspective of water, virtual water export should be proportional to the water availability. In China one can find the reverse situation. Apparently other factors than water—probably availability of fertile land in particular—have been determinants of the process which has led to the current situation. Even today, the approach is mainly supply-oriented. In 1999 south China imported 52 billion m^3 virtual water from north China. This was more than the maximum water transfer volume by the three routes of the south–north Water Transfer Project. The average water footprint per capita in China was 1049 m^3 yr^{-1}
(Potential) applications to policy	The big question remains: is bringing the water from south to north in virtual form worth its environmental consequences? From a water resources point of view this does not make sense. There must be other decisive factors to justify the strategy. Factors that could play a role are availability of suitable cropland, possibly labour availability or national food security.
Recommendations / limitations	A broader, integrated study would be required to give a more comprehensive assessment of the efficiency and sustainability of the south–north Water Transfer Projects.
Lacking	Grey water analysis
Sources	Ma, J., Hoekstra, A.Y., Wang, H., Chapagain, A.K. and Wang, D. (2006) Virtual versus real water transfers within China, *Phil. Trans. R. Soc. Lond. B.* 361 (1469): 835-842

3.4. Going against the flow: A critical analysis of inter-state virtual water trade in the context of India's National River Linking Program; 2009; The Water Footprint of India, (in press)

Author organisations	International Water Management Institute, India, UNESCO-IHE, University of Twente, Delft University of Technology (NL).
Short description and objectives	The Government of India has proposed a National River Linking Programme (NRLP) which envisages linking 37 rivers. The prime motivation being India's growing concern about the need to produce additional food for its rapidly increasing population, and thus expand its irrigation potential. This Inter Basin Water Transfer (IBWT) has been strongly criticised and a number of alternatives have been suggested to tackle the upcoming food requirements, between others, using virtual water trade, instead of physical water transfers, to deal with the high spatial variation in water availability across the country. This report analyses the real determinants of inter-state virtual water flows in India. It provides a preliminary assessment of the potential of virtual water trade to act as an alternative to the proposed IBWT.
Methodology / indicators used	- Virtual Water Content of traded products - Inter-state virtual water flows: identification of exporter and importer states. - Test the relationship between the water resources endowments of states and their relation with virtual water trade: net virtual water imports or exports vs water availability per region, under the frame of current food and agricultural policies. - Assessment of water scarcity in the Indian states: water scarcity is assessed from the production perspective by comparing water availability to the water use in a state, and from the consumption perspective by comparing water availability to the water footprint of a state. - Analyse other factors such as access to arable land and access per capita per state and access to secure markets per state.
Remarks	Results of the analysis of 16 primary crops. The studied period is 1997-2001. Grey water and water productivities included.
Innovative contribution	Virtual water flows per state plotted against per capita water availability per state (green, internal blue, total blue, and total water availability), per capita gross cropped area (access to arable land) and percentage of rice production (access to secure markets).
Conclusions	- States which enjoy a natural comparative advantage in terms of water endowments actually have a net import of virtual water. The existing pattern of virtual water trade is exacerbating scarcities in water scarce regions Trade of agricultural commodities between Indian states is not governed by water scarcity differences between the states. Factors like per capita availability of arable land, and food and agriculture policies like the regional water pricing policy have a more determinant influence on trade patterns. - The NRLP proposes to transfer excess flood waters from the Eastern, rich in water resources states, to the water scarce regions which produce the bulk of the food thereby ensuring India's national food security, which is in contradiction with the virtual water trade argument, which states that water rich states in eastern India should be producing much of India's food requirements and exporting food grains to the water scarce states. it is demonstrated that an increase in water productivity in the water abundant states has a better chance of reducing the national water scarcity than the proposed water transfer. - The national blue, green and total water scarcity from consumption perspective closely matches the national blue, green and total water scarcity from production perspective. This is because the net international export of virtual water is relatively small in India. The high water scarcity from production perspective in Punjab, Haryana, Rajasthan and Tamil Nadu is in line with the current status on water scarcity in the Indus, Luni and Cauvery river basins.
(Potential) applications to policy	The idea of using virtual water as a tool for water saving, or as an alternative to physical water transfers, has limited applicability in the current scenario. Water endowments alone are unable to explain the direction and magnitude of trade.
Recommendations / limitations	Virtual and real water transfers can be more accurately evaluated by carrying out an analysis at a more refined geographical scale such as a particular river link.
Lacking	
Sources	Verma, S., Kampman, D.A., Van der Zaag, P. and Hoekstra, A.Y. (2009) Going against the flow: A critical analysis of inter-state virtual water trade in the context of India's National River Linking Programme, *Physics and Chemistry of the Earth* 34: 261-269. Kampman, D.A., Hoekstra, A.Y. and Krol, M.S. (2008). *The water footprint of India.* In press.

3.5. The external water footprint of the Netherlands: Geographically-explicit quantification and impact assessment; 2009

Author organisations	**University of Twente**
Short description and objectives	The WF concept is used as an indicator of the water use related to levels of consumption and trade patterns in the Netherlands. This study quantifies the external WF of NL by partner country and import product. These results are confronted with water-scarcity indicators. In this way, hotspots in different parts of the world are identified where the external water footprint of the Netherlands expectedly has the largest impacts, and assesses the impact of this footprint by contrasting the geographically-explicit WF with water scarcity in the different parts of the world.
Methodology / indicators used	- Calculation of the total national WF: Comparison between two calculation approaches: bottom-up and top-down. - Calculation of the total use of domestic water resources (WU), virtual-water import (V_i) and export (V_e) and internal and external components of the Dutch WF (WF_i, WF_e). - Comparison of WF_e, and Vi to indicators of water scarcity or stress. - Identification of hotspots. - Identification of the blue, green and grey WF per hotspot.
Remarks	- Calculations done for the period between period 1996–2005. - Grey water analysis included. - Bottom-up methodology used
Innovative contribution	- The bottom-up approach is applied to calculate the national water footprint. - Local WF Impact Assessment analysis. - Compilation of water-scarcity indicators. - Identification of hotspots.
Conclusions	- The bottom-up approach to calculate the WF is more reliable for a country as the Netherlands, where trade flows are large if compared to domestic production. The outcome of the top-down can be very vulnerable to relatively small errors in the input data. - The total water footprint of the Netherlands is estimated to be about 2300 m^3/year/cap. About 11% of the water footprint of the Netherlands is internal and 89% is external. Dutch consumption implies the use of water resources throughout the world - Hotspots are: China; India; Spain; Turkey; Pakistan; Sudan; South Africa; and Mexico. Although these countries are not the largest contributors to the external water footprint of Dutch consumers in absolute terms, in these countries the negative externalities of Dutch consumption are considered to be most serious. Dutch consumption implies the use of water resources throughout the world, with significant impacts in water-scarce regions.
(Potential) applications to policy	The results of this study can be an input to bilateral cooperation between the Netherlands and the Dutch trade partners aimed at the reduction of the negative impacts of Dutch consumption on foreign water resources. Dutch government can also engage with businesses in order to stimulate them to review the sustainability of their supply chains.
Recommendations / limitations	
Lacking	Articulation into policy
Sources	Van Oel, P., et. al. The external water footprint of the Netherlands: Geographically-explicit quantification and impact assessment. *Ecological Economics* 69 (2009) 82–92.

3.6. UK Water Footprint: the impact of the UK's food and fibre consumption on global water resources; 2008

Author organisations	WWF
Short description and objectives	This study examines the impact of the UK's consumption patterns on water resources across the world. WWF's intention in publishing this report is, (i) to start a debate about how UK-based organisations can help to ensure that critical, and often scarce, water resources are managed wisely, and (ii) to challenge government to support laws that address water use in the UK and the EU, and to fully consider water in crucial development strategies overseas where the WF has the greatest impacts. This is done by estimating the WF of the nation, estimating and analysing its different components and discussing the UK WF in the context of water stress sites of production. Key features of the UK WF are highlighted through selected case studies. Finally, actions for key stakeholders are recommended.
Methodology / indicators used	- Calculation of virtual water import or export: traded commodities are multiplied by their VWCs at exporting locations. - Calculation of the national WF and its external and internal components (top-down approach). - Impact Assessment of the external WF: Water scarcity indicator (water withdrawal to water availability taking into account Environmental Flow Requirements) applied and hotspots identified. - Specific case studies per product: Sugar crops, tomatoes and cotton products. - Specific case studies per hotspot: Spain, Morocco, Pakistan.
Remarks	Top-down approach used: WF = Total Water Use + Virtual water import – Virtual water export.
Innovative contribution	Solutions and implications for key stakeholders (government, businesses and the general public) included.
Conclusions	The UK WF is, in global terms, very high per person. These results show that the UK is just 38% self-sufficient in water (the ratio of internal to total WF), and is therefore 62% dependent on water from elsewhere. The impact of an increase or decrease in the UK's WF depends entirely on where water is taken from and when. The increase of a WF in an area where water is plentiful is unlikely to have an adverse effect on society or the environment, but an increase in an area already experiencing water scarcity could result in serious problems, such as the drying up of rivers, the destruction of habitats and livelihoods as well as the extinction of species., in addition to affecting agricultural prices, supplies and local economies. Finally, if you import, your imports need water, and if water is poorly managed or scarce where you source, your imports will be at risk in terms of quantity, quality or price.
(Potential) applications to policy	Many recommendations are given. Between others: - Incorporate sound water management as a key plank of UK aid strategy with a much higher priority and funding allocation. - Measure the water needed to meet food security/ consumption for the UK, the EU and globally and the implications for UK policy support. - Facilitate dialogue and links (at UK and EU levels) between business and government with regard to impacts on water sources at production sites.
Recommendations / limitations	A crude assessment of the industrial WF of the UK was made, based on the best available methods, which need improvement. Data is lacking.
Lacking	Grey Water analysis is presented for just one product (cotton)
Sources	Chapagain, A. K. and Orr, S. (2008) UK Water Footprint: The impact of the UK's food and fibre consumption on global water resources, Volume 1, WWF-UK, Godalming, UK.

3.7. The Water Footprint of Germany: where does the water of our food come from?; 2009.

Author organisations	WWF
Short description and objectives	This study intends to present the concept of virtual water and the water footprint to broad public attention. Since Germany imports virtual water, it is important to know which countries are affected by this virtual water trade and which products have the greatest water consumption. The focus of this study therefore was placed explicitly on imported goods, their virtual water content and the connected possible consequences.
Methodology / indicators used	- Calculation of the virtual water content of crops and livestock: internal and external agricultural WF - Calculation of the WF of industrial goods using best available methods. - Quantification of domestic water uses - Assessment of virtual water imports: 15 most important production countries and main agricultural products imported – identification of critical products. - Impact Assessment of the external WF: Water scarcity indicator applied and hotspots identified. - Proposition of solutions and recommendations
Remarks	Database used for the period 2004-2006. Main focus on the agricultural sector: 503 crop and 141 livestock products were taken into account.
Innovative contribution	Solutions and implications for key stakeholders (government, businesses and the general public) included.
Conclusions	The water footprint of Germany is 159.5 cubic kilometres of water per year, that is, 5,288 litres of water per capita each day. The imported goods with the highest water footprint are coffee, cocoa, oilseeds, cotton, pork, soybeans, beef, milk, nuts and sunflowers. The biggest water footprint of Germany is left in Brazil, Ivory Coast, France, the Netherlands, the USA, Indonesia, in Ghana, India, Turkey and Denmark. In the producing countries different production standards are applied under the respective climatic, demographic and economic conditions. Five countries where the export of virtual water has negative consequences for the natural ecosystems as well as on the social and economic sectors are: Brazil (pollution problems), India (pollution, social and economical impacts), Kenya (deforestation), Spain and Turkey (illegal water abstractions).
(Potential) applications to policy	This study does not only want to inform about where Germany leaves its water footprint and which consequences derive from that. Companies and governments should be addressed with this report to develop measures that implement the virtual water concept in order to effectively reduce the water consumption and at the same time reduce the impacts of their actions in other countries. The German government should raise the financial means in development co-operation where improvements in the sustainable management of aquifers are aspired as well as in river catchment areas, especially in water-scarce regions, where water mismanagement is practised. At the European level, the consistent implementation of the EU Water Framework Directive for rivers and aquifers should be demanded – especially in the Mediterranean countries of Spain, Italy and Greece, but also in the EU candidate country Turkey as well as other riparian countries. Agricultural subsidies of the EU should only be paid in the case of proven responsible utilisation of the water resources.
Recommendations / limitations	The external water footprint of Germany has a national level of resolution. A more refined resolution (hydrological catchment area) would be necessary for the detailed assessment of the actual ecological and social consequences of the WFs. The available data only allow general information at first about the amount of water taken from a certain country as agricultural good.
Lacking	Grey water (only included for the analysis of cotton)
Sources	Sonnenberg, A., Chapagain, A., Geiger, M., August, D. (2009) Water Footprint of Germany: where does the water for our food come from?, WWF-Germany, Frankfurt.

3.8. A comprehensive water balance of Tunisia: blue water, green water and virtual water; 2008.

Author organisations	Ecole National d'Ingénieurs de Tunis, Ministère de l'Agriculture et des Ressources Hydrauliques, Tunis.
Short description and objectives	A comprehensive water balance which includes the total water resource potential and the total water requirement including water used for food production is applied to Tunisia. This approach to water management is used to assess present and future water resource development and allocation in the country. All kinds of water resources are taken into account in the study (except grey water): withdrawal (blue) water, (green) water in rainfed agriculture and the net contribution of "virtual water" to the food import–export balance.
Methodology / indicators used	- Analysis of Tunisian blue water resources potential and demand projections, for the period 1996 - 2030. - Calculation of the "water-equivalent" requirement (virtual water) for production and trade of foodstuffs, between 1990 – 1997. Equivalent-water for food demand is split into: local food production (rainfed and irrigated agriculture), food export, food import and food consumption. - Assessment of water demand from different sectors in Tunisia: Irrigation, rainfed agriculture, deficit of food balance (imported virtual water), urban, industry, forests and rangelands, storage in dams for droughts, environment. - Formulation of equations representing the water balance in the country for a year n and calculation of the projected deficit in food requirement, expressed as equivalent-water.
Remarks	This work uses a different terminology to refer to the same concepts. Database used for the period 1990-1997.
Innovative contribution	All kinds of water, including water embedded in rainfed agriculture and international food trade are taken into account in a comprehensive water balance that is used to do a water resource planning in Tunisia.
Conclusions	The direct demand for blue water resource (domestic water, industry, tourism), which is an absolute priority in resource allocation, is relatively insignificant. The most significant part of the water resource is allocated for irrigation. The equivalent-water for the food requirements about 1300 m3/year per capita. This includes the water required for agricultural production (rainfed and irrigated) and that of imported food. Rainfed agriculture production (especially cereals, leguminous plants, olives), in terms of equivalent-water, contributes significantly (more than half) to the food demand. Food imports contribute significantly too, which serves to meet the deficit in the local produce, especially that from rainfed agriculture (which is very variable because of rainfall variability). The application of the mass balance equations allows an easy interpretation of the factors which play a role in the comprehensive water balance. The most important factor in this balance is the evolution of the food demand (depending on population and diet changes). The direct use related to urban, industrial and tourism sectors as well as the environmental demand has a relatively small impact on the comprehensive water balance. The projections show that the competition for limited water resources will require the transfer of water from agriculture to domestic and industrial water uses. The water allowance for agriculture will on average be of poor quality as good-quality water is required for urban water use. Equations also show that if the irrigated sector production is assumed constant, then the increase in food consumption can be met by improving rainfed agriculture production or by increasing virtual water imports (virtual water budget). Comprehensive water resource management indicates that the improvement in food security will depend on the ability of the country to manage and optimise the use of all kinds of water resources. The water scarcity indicators of a nation should ideally refer to the sum total of the water resources: blue water referring to the use of ground and surface water and green water referring to the water reserves of the soil.

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Continued

Author organisations	Ecole National d'Ingénieurs de Tunis, Ministère de l'Agriculture et des Ressources Hydrauliques, Tunis.
(Potential) applications to policy	The official policy aims at increasing the area under irrigation by 2030 by vastly improving water efficiency. Under these conditions of water resource limitation, it would be judicious to develop the irrigation potential. A realistic solution proposed out of the results of this study, but nevertheless ambitious in the long term, could be to stabilize the irrigated surface at a level such that the increase in the efficiency of agricultural water use could compensate for the reduction of the agriculture water allocation.
Recommendations / limitations	
Lacking	Procedure to calculate the water-equivalent (virtual water content) from crops. How was the water from import products calculated?
Sources	Chahed, J., Hamdane, A. and Besbes, M.(2008) 'A comprehensive water balance of Tunisia: blue water, green water and virtual water', *Water International,* 33: 4, 415 — 424.

3.9. The water footprint of Indonesian provinces related to the consumption of crop products; 2009

Author organisations	**University of Twente (NL)**
Short description and objectives	The aim of this report is to quantify inter-provincial virtual water flows related to trade in crop products and determine the water footprint related to the consumption of crop products per Indonesian province.
Methodology / indicators used	- Calculation of the WF of the most important crops (green, blue and grey components). - Calculation of inter-provincial virtual water flows, which result from crop trade between provinces. - Calculation of the WF per province related to the consumption of crop products, and its internal and external components (analysis of international virtual water flows included).
Remarks	Data between 2000 – 2004 used for the calculations.
Innovative contribution	Grey water footprints included
Conclusions	The water footprints of crops largely vary among provinces. Rice produced on Java has the lowest water footprint of all rice in Indonesia. The green water component is relatively high for all crops; only for rice and soybeans the contribution of irrigation water is relatively high compared with other crops. The green component gives the largest contribution to the water footprint related to the consumption of crop products. The inter-provincial virtual water flows are primarily caused by trade in rice. The products cassava, coconut, bananas and coffee have the largest inter-provincial water flows relative to the water use for production. The biggest amount of virtual water from provinces or countries goes to Java, a densely populated island where the production of crops is not sufficient to satisfy the total consumption. Sumatra has the largest contribution in the virtual water export. The provincial water footprint varies between 859 and 1895 m3/cap/yr. The average provincial water footprint consists for 84% of internal water resources. The remaining 16% comes from other provinces (14%) or countries (2%). All island groups except Java have a net export of water in virtual form. Java, the most water-scarce island, has a net virtual water import and the most significant external water footprint. This large external water footprint is releasing the water scarcity on this island.
(Potential) applications to policy	In order to ensure stability, economic growth and food security, it has been recognised that the government has to reform the water policy in Indonesia. Indonesian water footprint may be reduced by promoting wise trade between provinces – i.e. trade from places with high to places with low water efficiency. On the other hand, the water footprint can be reduced by improving water efficiency in those places that currently have relatively low efficiency, which equalises production efficiencies and thus reduces the need for imports and enhances the opportunities for exports. In any case, trade will remain necessary to supply food to the most densely populated areas where water scarcity is highest (Java).
Recommendations / limitations	
Lacking	Livestock products not included
Sources	Bulsink, F., Hoekstra, A.Y. and Booij, M.J. (2009) 'The water footprint of Indonesian provinces related to the consumption of crop products'. Value of Water Research Report Series, UNESCO-IHE, 37.

3.10. The water footprints of Morocco and the Netherlands: Global water use as a result of domestic consumption of agricultural commodities; 2006.*

Author organisations	University of Twente, NL.
Short description and objectives	The aim of this report is to assess the WF of Morocco, a semi-arid/arid country and the Netherlands, a humid country.
Methodology / indicators used	Calculation of: - Virtual water contents of agricultural commodities at the places of production. - International virtual water flows by multiplying commodity trade flows by their associated virtual water contents. - Agricultural WFs of national consumption (top-down approach used), and its internal and external components. - Water dependency and water savings.
Remarks	Period of analysis between 1997 - 2001. Calculations for 285 crop products and 123 livestock products.
Innovative contribution	Makes use of novel concepts such as "virtual water content" of a commodity, the water footprint of a nation and the water saving as a result of international trade.
Conclusions	Morocco (population of 28 million people), has an agricultural WF of 42.1 billion m^3/yr. The external WF of Morocco is 6.3 billion m^3/yr. It has thus a water dependency of 14%. Morocco mostly depends on virtual water import from France, the USA, Canada, Brazil and Argentina. Cereals and oil crops are the most important source of virtual water import. Others are stimulants and sugar. The export of virtual water from Morocco relates to oil crops, fruits, cereals and livestock products. About 4% of the water used in the Moroccan agricultural sector is applied for producing export products. Morocco has an average agricultural WF of 1477 m^3/cap/yr. Climate (growth conditions) and agricultural practice (water use efficiency) are unfavourable factors contributing to increase the Moroccan WF. Domestically producing the agricultural products that are currently imported to Morocco would require 28.6 Gm^3/yr. Thus, global water saving is (28.6 – 6.3=) 22.3 Gm^3/yr.
(Potential) applications to policy	International trade of agricultural commodities depends on a lot more factors than water, such as availability of land, labour, knowledge and capital, competitiveness in certain types of production, domestic subsidies, export subsidies and import taxes. As a consequence, international virtual water trade can most of the times not be explained on the basis of relative water abundances or shortages. But from a water resources point of view, it seems appropriate that most of the scarcely available water in Morocco is being used for producing commodities for domestic consumption and not for export. From an economic point of view it would be worth checking whether the exported commodities yield a relatively high income of foreign currency per unit of water used (not done in this study). If food self-sufficiency would not be an issue, from a water-resources point of view it would make sense to stimulate export of products with a relatively high foreign currency income per unit of water used (e.g. citrus fruit, olives) and to import products that would otherwise require relatively a lot of domestic water per unit of dollar produced (e.g. cereals).
Recommendations / limitations	The study is limited to agricultural commodities
Lacking	Grey Water not included
Sources	Hoekstra, A.Y. and Chapagain, A.K. (2006) 'The water footprints of Morocco and the Netherlands'. Value of Water Research Report Series, UNESCO-IHE, 21.

* This summary presents results for Morocco. An updated study for the Netherlands has been done, see example 3.5 of this annex.

3.11. Virtual Water Trade and the Water Footprint of Cyprus: alternative tools in managing water resources; 2008.

Author organisations	University of Edinburgh, UK.
Short description and objectives	The concepts of virtual water and water footprint are applied to Cyprus, in order to quantify the virtual water flows in relation to trade and to estimate the water footprint of Cyprus arising from the consumption of agricultural products. Other objectives are: - Quantify the net virtual water savings arising from agricultural trade - Identify which particular agricultural products are more water-intensive and quantify the exported volume of virtual water of Cypriot origin; and - Analyse the Cypriot agricultural water use by distinguishing between irrigation and rain-fed agriculture.
Methodology / indicators used	- Water balance and water demand analysis for Cyprus - Calculation of the virtual water content of primary crops and of processed crop and livestock products (at places of production). - Virtual water flows of traded agricultural products - Water savings, water scarcity, self sufficiency and import dependency of Cyprus.
Remarks	The study covers 285 crop products and 123 livestock products for the period 1996 – 2006; differentiation between blue and green water. Partial study, results under revision.
Innovative contribution	Overall the study provides additional information on agricultural water use which has been absent from the water demand assessment in Cyprus.
Conclusions	The average per capita agricultural water footprint of Cyprus is found to be 2,028m^3/year and the average national total agricultural water footprint is 1,435Mm^3/year, of which 1,110Mm^3/year is attributed to imported virtual water through agricultural products (89 Mm^3/year are re-exported) and 414Mm^3/year correspond to the internal WF of the country. The four major factors that determine the water footprint of a country, (a) volume of consumption, (b) the consumption pattern, (c) climatic growth conditions and (d) agricultural practice, are equally applicable to the Cyprus case. Cyprus appears to have net savings from trade in agricultural products since overall it imports more virtual water than exports.
(Potential) applications to policy	The policy of the Cypriot government has encouraged farmers to specialise on cash crops that are demanded in foreign markets yet in most cases such crops have high water requirements, with respect to the climatic conditions of the country. Agriculture utilises the majority of water resources in the country (69%) and contributes to a limited extent to the national output (2.5%) and workforce employment (7%) compared to the service sector. Thus from an economic point of view it can be argued that water could have been allocated to more water efficient sectors other than agriculture with probable higher marginal returns. Having in mind that irrigation water in Cyprus derives either from costly water development works (dams and conveyance schemes) or from the over-extraction of groundwater resources, it could be argued that if exports of water demanding crops were to be avoided, a substantial amount of usable water could remain within the local environment and/or economy. The current high water demanding crop pattern in Cyprus is driven by the subsidised irrigation policy of the government, which can explain the substantial amount of exported blue crop water use. Given the water availability and climatic conditions of the country, cropping patterns need to be modified towards rain-fed agriculture and concentrate on less water demanding crops like flowers, aromatic plants and winter crops which generally depend on rainwater. This will require strong political will and government intervention to convince the farmers towards such agricultural practises. In such a reallocation of water resources, policy makers will need to consider the opportunity cost of water in alternative uses. On the other hand, Cyprus is already dependant on imports and further import dependency could have negative political and economic implications by making the country vulnerable to price fluctuations in the global food market.
Recommendations / limitations	The study is limited to agricultural commodities
Lacking	Grey Water not included
Sources	Zoumides, C. (2008). Virtual Water Trade and the Water Footprint of Cyprus: alternative tools in managing water resources. Dissertation for the degree of MSc in Ecological Economics, School of GeoSciences, the University of Edinburgh.

Annex II SUMMARY OF THE WATER FOOTPRINT ACCOUNTING TOOLS APPLIED BY THE CASE STUDIES

Period 2004-2009

Geographic unit	Sector/Process WF				WF component			WFarea, cons		VW flows	WF acc scheme[11]	Period of time
	Crop	Livestock	Industry	Domestic	blue	green	grey	External	Internal			
Global												
The WF of nations[1]	Y	Y	Y	Y	-	-	-	Y	Y	Y	Y	1997-2001
National												
UK[1,2]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y[4]	-	2006
NL[2]	Y	Y	Y[1]	Y	Y	Y	Y	Y	Y	Y[4]	Y	1996-2005
Germany[2]	Y	Y	Y[3]	Y	Y	Y	Y	Y	Y	Y[4]	-	2004-2006
China	Y	Y	-	-	Y	Y	-	-	-	-	-	1961-2003
India	Y[5]	-	-	-	-	-	-	-	-	Y[6]	-	1997-2001
Indonesia	Y	-	-	-	Y	Y	Y	-	-	Y[6]	Y	2000-2004
Tunisia[7]	Y	Y	-	-	-	-	-	-	-	Y[8]	-	1990-1997
Morocco[1]	Y	Y	-	-	-	-	-	Y	Y	Y	Y	1997-2001
Spain[1]	Y	Y	Y	Y	Y	Y	-	Y	Y	Y	Y	1997-2005
Cyprus[1]	Y	Y	-	-	Y	Y	-	Y	Y	Y	-	1996-2006
Regional and river basin												
La Mancha region[9], Spain	Y	-	-	-	Y	Y	-	-	-	Y	-	1997, 2001, 2005
Doñana region, Spain	Y	-	Y	Y	Y	Y	Y	-	-	-	-	2001
Guadiana river[10], Spain	Y	Y	Y	Y	Y	Y	-	-	-	Y	-	1997, 2001, 2005
Guadalquivir river, Spain	Y	Y	Y	Y	Y	Y	-	-	-	Y	-	1996-2004
Lower Fraser valley and Okanagan basins	Y	Y	-	-	Y[12]	Y[12]	-	-	-	-	-	1995-2005 [13]
Heihe river basin, China	Y	Y	-	-	Y	Y	-	-	-	Y	-	2001-2002

Y = Yes
1 Top-down approach
2 Blue, green and grey WF distinguished for some products or hotspots
3 Rough estimation
4 Flows from abroad to the nation (imported virtual water)
5 Sixteen primary crops
6 Inter-provincial virtual water flows
7 The study for Tunisia uses a different terminology as the one presented in this table
8 Imported and exported virtual water
9 ground and surface water distinguished in the blue water component.
10 Green and blue water components for the most representative crops. Blue water components for livestock, industrial products and domestic water use (Agricultural WFs differentiated into ground and surface water).
11 Water Footprint Accounting Scheme.
12 There is thus no differentiation between agricultural green and blue WF, only total Crop Water Use included.
13 Climatic data. Yield data used for 1991 and 2001

2

Jason Morrison
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Corporate Water Accounting:

An Analysis of Methods and Tools for Measuring Water Use and Its Impacts

April 2010

UNEP

The CEO Water Mandate

PACIFIC
INSTITUTE

Executive Summary

PROBLEM STATEMENT

Water as a natural resource is facing many challenges at the local, regional, and global levels. Human water use is increasingly having negative impacts on human health, economic growth, the environment, and geopolitical stability. In recent years, concerns over growing water scarcity, lack of access to water to meet basic human needs, degraded ecosystem function, and the implications of climate change on the hydrologic cycle have brought water to the forefront as a strategic concern for companies around the world.
Companies' ability to measure and account for their water use and wastewater discharges throughout the value chain is a critical component in their risk assessment and mitigation efforts, as well as their broader ambitions to become responsible water stewards. Corporate water accounting also allows consumers, civil society groups, and the investment community to compare different companies' social and environmental impacts in order to inform their actions and decision making.
In sum, the ability to effectively account for corporate water use and impacts is essential in helping companies drive improvement and become aligned with external stakeholders' expectations, as well as their efforts to advance sustainable water management.

However, collecting and disseminating meaningful water-related information is a complicated and difficult undertaking. And while corporate water accounting methods and tools have been under development for the past decade, there is still near universal agreement that current methods—though a good start—are inadequate and need to be refined.

PROJECT OBJECTIVES AND METHODOLOGY

This stocktaking exercise—a joint effort of the United Nations Environment Programme (UNEP) and the CEO Water Mandate—aims to assess existing and emerging water accounting methods and tools being used in the private sector, with the goals of:

• Elucidating commonalities and differences among emerging methods and practice;

• Identifying gaps and challenges;
• Suggesting where accounting methods might benefit from harmonization and increased field testing.

Our analysis focuses primarily on four main methods/tools:

• The Water Footprint Network's "water footprint": A method for measuring the volume of water used by any group of consumers (including a business or its products) that is intended to help those consumers better understand their relationship with watersheds, make informed management decisions, and spread awareness of water challenges.

• Life Cycle Assessment: A systems analysis tool designed specifically to measure the environmental sustainability of products (including water use/discharge and many other resource uses/emissions) through all components of the value chain.

• WBCSD Global Water Tool: A free online platform that couples corporate water use, discharge, and facility information input with watershed- and country-level data as a means of assessing water-related risk.

• GEMI Water Sustainability Planner/Tool: Two free online tools meant to help companies better understand their water-related needs and circumstances. The Water Sustainability Tool assesses a company's relationship to water, identifies associated risks, and describes the business case for action. The Water Sustainability Planner helps elucidate a facility's dependence on water and the status of the local watershed.

In an appendix to this report, we provide a brief overview of several water accounting methods that are regionally/nationally specific, industry-sector specific, or proprietary and therefore not included in our analysis. In addition, the International Organization for Standardization (ISO) is currently developing a standard for water accounting that is highly relevant to this research, though is not included here because the standard is in its early stages.

Water accounting—as well as companies' need for and use of it—has evolved significantly over time. In exploring these needs and their evolution in recent years, we summarize when and for what reasons companies are seeking to use existing methods and tools, along with the questions they are asking with regard to their corporate water use/discharge and the resulting impacts and business risks. Because current water accounting methods and tools all have different histories, intended objectives, and outputs, we explicate these origins and core functions in order to shed light on the circumstances for which various methods and tools may (or may not) be appropriate and effective.

Corporate water accounting today can be seen as serving four general, inter-related applications:

1. Operational efficiency, product eco-design, sustainable manufacturing
2. Water risk assessment/identification
3. Managing water-related social and environmental impacts and water stewardship response
4. Communicating water risk/performance with stakeholders

These areas of interest to companies represent the broad types of methods and tools available and are motivated by a number of factors, including pursuit of reduced costs, strategic planning, brand management/corporate reputation, and corporate ethics/philanthropy. However, at their root, they are all driven by the desire to identify and reduce water-related business risk (and seize opportunities), whether through building competitive advantage, ensuring long-term operational viability, or maintaining and/or improving social license to operate. Because understanding and mitigating the inter-related issues of water risk and impact is a core driver for emerging water accounting methods and tools, they are explored extensively in this analysis.

FINDINGS

Our analysis has resulted in a number of key findings, including those pertaining to: 1) the areas in which corporate water accounting in general is lacking, 2) the similarities across all four general applications covered in the study, and 3) the characteristics, strengths, and weaknesses of specific methodologies and tools. Conclusions about the four application areas and water accounting in general are listed below, while conclusions regarding the main methods/tools assessed are summarized in Table ES-1. We conclude with a list of recommendations for improving corporate water accounting in the future.

Overarching conclusions:

1. Terminology confusion: The term "water footprinting" is frequently used by different interests to mean very different things. Most notably, for many, it is used as an umbrella term for all water accounting methods connoting a volumetric measurement of water use that reflects water-related impacts. This usage of the term is similar to the way that many understand carbon footprinting. However, water footprinting—as defined by the Water Footprint Network (WFN)—is in fact fundamentally different from carbon footprinting in a number of key ways, especially with regard to the assessment of impacts, which the WFN excludes. Because of this varied understanding, any claims or conclusions made about "water footprinting" should be scrutinized carefully.

2. Shift toward external factors: The extent to which a company has water-related business risks is largely dependent on the socio-political, environmental, and geo-hydrologic contexts in which the company and its suppliers operate. As such, corporate water accounting has transitioned from a primarily inward focus on production processes to an outward focus that entails the social, political, environmental conditions of the watersheds in which companies operate.

3. Lack of harmonization: Being a nascent field, the approaches used by businesses to measure and report water-related risks and impacts vary significantly among companies and industry sectors. In addition, methods for characterizing watershed conditions are still largely underdeveloped. As such, it is often difficult for companies to compare their water risks and impacts, and benchmark their progress against that of other companies. Furthermore, it makes it difficult for external stakeholders to accurately assess companies' risk and impacts.

4. Supply chain issues underemphasized: Companies are increasingly recognizing that a significant portion of their water-related risks and impacts can occur in their supply chain rather than their direct operations. Yet this component of corporate water accounting remains relatively underdeveloped. This is due partly to the challenge of collecting and managing data from often hundreds of different suppliers, as well as the fact that many companies (e.g., those that source supplies in global commodity markets) are not able to track water

issues relating to their supplies.

5. Inadequate data: A lack of sufficient data is in many cases the greatest factor limiting the ability of corporate water accounting to provide meaningful information on water-related impacts and risks. This is most often due to inadequate databases, lack of access to existing data, or insufficient granularity of data.

6. The water-energy-carbon nexus: Companies are increasingly acknowledging that water-related impacts and risks are inextricably linked to their energy use and carbon emissions. Sustainability accounting methods are only beginning to develop efficient ways to align such assessments and highlight linkages.

Findings regarding the four application areas

Operational efficiency, product eco-design, sustainable manufacturing:

Companies simply seeking to improve the efficiency of their operations with respect to water use and discharge may require relatively little knowledge of watershed conditions in which they operate. Although the need for operational efficiencies may be greater in certain locations due to water stress, the process through which these improvements are achieved is typically not dependent on the local context. Thus, companies can often track operational efficiencies using internal production data alone. That said, efforts to make "eco-friendly" products are predicated on assessing external factors, which will require watershed-level, local context data.

Water risk assessment/identification

Water-related business risks are associated not only with the impacts of corporate water use/discharge on the surrounding environment, but also changing external social, environmental, and political conditions in places where the company operates. As such, risk can be effectively assessed using a number of different approaches, including the four main methods/tools evaluated in this study. Conducting a simple "first-tier" risk screen that identifies at-risk operations or value chain stages that are likely to have water issues is quick and relatively inexpensive, and can be done without extensive detailed internal or external data. However, conducting a comprehensive assessment that considers the specific local social, environmental, and political conditions that create risk in a particular locale requires detailed data on both internal water use/discharge and local watershed conditions. Such data collection requirements can be resource intensive and are often hindered by a paucity of primary data.

Managing water-related social and environmental impacts and water stewardship response

Accurately assessing the social and environmental impacts of a company's water use/discharge is an important component in any comprehensive corporate water accounting exercise. Yet methods for assessing such water-related impacts are currently underdeveloped. This is partly due to the data limitations mentioned above, but also due to a lack of agreement among practitioners on the appropriate range of social and environmental impacts that must be addressed, as well as consensus on the methods by which such impacts are characterized. A detailed assessment of impacts could consider a number of different environmental and social factors, including physical abundance of water, human access to water, affordability of water services, human health issues, and ecosystem function/biodiversity, among others. However, at present there is no consensus in the field of corporate water accounting as to the appropriate scope of such impact assessments.

Communicating water risk/performance with stakeholders

Companies are increasingly using their water accounting outputs to support their disclosure to key stakeholders and the general public as a strategy for improving transparency and accountability. Traditionally, quantitative water data disclosed has focused on indicators such as total water use, discharge, and/or recycling. This information alone is now widely considered inadequate as it does not address the local contexts in which the water is used. As corporate water accounting has evolved from an inward to outward focus over the years, a corollary shift in demand for supporting information has taken place. New initiatives, such as the Carbon Disclosure Project, underline that such disclosure of risk-related and location-specific information is now an expectation of companies.

ES-1 Summary of Findings on Corporate Water Accounting Methods and Tools

Application:	Water Footprint	Life Cycle Assessment	WBCSD Global Water Tool	GEMI Water Sustainability Tools
General Strengths	• Good tool for "big picture" strategic planning purposes • Easily understood by non-technical audiences • Best for water use assessments, as opposed to water quality	• Uniquely well-suited for cross-media environmental assessments • Mature science-based methods for assessing water-quality impacts	• Good first-tier risk screen • Inexpensive, fast, and does not require company expertise • Simple inventory for companies to compile their water data	• Useful for companies just beginning to think about water stewardship • Inexpensive, fast, does not require expertise
General Weaknesses	• Generic, aggregated blue-green-grey WF[1] figures are misleading • Grey WF deemed ineffective by many companies	• No universally accepted method of assessing water use impacts • Results can be difficult to communicate to non-technical audiences	• Does not address water quality/ discharge-related risks • Does not address impacts • Assessments provide only rough estimates of risk	• Rudimentary assessment of relative risks • No quantified results
Assessing Water-Related Business Risks	• Identifies "hotspots" linking corporate consumptive water use and source water data • Green/blue WF distinction helps shed light on nature of risk	• Uses science-based impact assessment as the starting point for understanding business risk • Operational "hotspots" used for product design improvement, technical improvements	• Emphasizes place-based water metrics that contextualize company water use and that serve as the basis for understanding risk • Identifies "hotspots" by mapping facilities against external water and sanitation data	• The Planner assesses external factors that affect specific facilities • The Tool helps companies identify business-wide water-related risks
Understanding and Responding to Water Use and Quality Impacts	• WF calculation does not attempt to quantify water-related impacts • Green/blue WF distinction illustrates general extent and type of impact • Gray WF underdeveloped/ underutilized – focuses on primary pollutant and calculates theoretical volume of dilution water needed to reach regulatory standards	• Situates water impacts within a broader understanding of sustainability impacts • Characterizes water use data based on relative water stress to quantify impacts • Measures individual contaminant loads • Does not typically quantify impact to specific local receiving bodies	• Does not characterize corporate water use or otherwise attempt to assess impacts • Does not assess water quality issues	• Provides a compilation of information that can help better understand and identify impacts, but does not quantify them • Provides questions that help companies understand their effects on quality of water bodies
Conveying Water Information to Stakeholders	• Can be an effective public-awareness building tool • Conducive to business engagement with water resource managers	• In many instances, particularly in North America, is used for internal purposes only • Awareness levels in both business and the public vary greatly • Used to inform ecolabel programs	• Results of "hotspotting" are more frequently being included in CSR reports • Automatically calculates water-related GRI indicators to be used for CSR reports	• Is not intended for use as a communication tool, nor is it commonly used as one

[1] Water footprints are divided into three separate components—the blue, green, and gray WFs—which differentiate water use by source/type (surface/groundwater, evaporative flows, dilution water respectively) and are meant to be considered both separately and together as a total WF.

Recommendations

In our analysis, we identified six key areas in which water accounting practices can be improved through emerging practice. These improvements can manifest themselves through the field testing that UNEP is planning within its multi-year WaFNE Project, or the efforts of other corporate water stewardship initiatives.

- **Common definitions:** Reaching broad consensus on an acceptable definition of the term and concept of "water footprinting" is essential moving forward in order to clarify communication of important information among companies and allow non-technical audiences, including consumers and investors, to more easily understand and engage with this field.

- **Assessment of local water resource context:** Corporate water accounting must better measure and more consistently characterize the local external contexts in which companies operate. In particular, a better understanding of the social dimensions (e.g. accessibility, affordability) of water resources is needed. Companies, practitioners, and other stakeholders stand to benefit from reaching agreement on appropriate and effective "local context" metrics and better ways of working together to collect and manage the relevant watershed-based information.

- **Harmonized reporting criteria:** In order to support companies' and stakeholders' ability to assess corporate water risks, impacts, and performance and guide future corporate water stewardship practices, a more consistent approach to measuring and communicating water-related information must be developed. Such information should be relevant across industry sectors and regions and must be valuable for companies themselves, while addressing external stakeholder needs.

- **Improved data collection:** Since many corporate water accounting efforts are limited by insufficient corporate water use and external watershed data, emerging best practice should focus on building the capacity of operations managers to develop and manage more robust information systems.

- **Assessment of supply chain:** More robust and systematic ways to address suppliers' water issues must be developed. Building out this relatively underdeveloped aspect of corporate water footprinting can be accomplished by focusing on standardized and improved data collection systems in complex supply chains—and innovative ways to communicate and incentivize this focus to suppliers.

- **Addressing water quality:** Priority should be given to developing more effective ways of accounting for wastewater discharge/water quality, assessing related impacts on ecosystems and communities, and "characterizing" ambient water quality in the watersheds in which companies operate.

- **Cooperation among companies:** There is an opportunity for companies to pool resources in their efforts to better measure and contextualize their relationship with water resources and contribute to sustainable water management. Companies can expedite the advancement of water accounting practices by sharing policies and programs, watershed and supplier data, innovative technologies, and effective reporting criteria.

The authors would like to recognize and thank the members of the Research Advisory Committee (RAC) for their invaluable insights and contributions throughout the development of this report. A full list of RAC members can be found in Appendix A. We also wish to thank others who helped develop and review this report including representatives from endorsing companies of the CEO Water Mandate, representatives from various civil society organizations, and staff of the Pacific Institute who provided valuable insight and editing suggestions.

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Preface

The United Nations Environment Programme's Division of Technology, Industry, and Economics (UNEP DTIE) commissioned this report from the Pacific Institute in its capacity as part of the CEO Water Mandate Secretariat. The report is one component of the broader UNEP Water Footprint, Neutrality, and Efficiency (WaFNE) Umbrella Project.

The CEO Water Mandate is a UN Global Compact initiative designed to help the private sector better understand and address its impacts on and management of water resources. Recognizing the urgency of the emerging global water crisis, the UN Secretary-General, in partnership with a number of international business leaders, launched the Mandate in July 2007. Endorsing CEOs acknowledge that in order to operate in a more sustainable manner, and contribute to the vision of the UN Global Compact and the realization of the Millennium Development Goals, they have a responsibility to make water resources management a priority, and to work with governments, UN agencies, non-governmental organizations, and other stakeholders to address this global water challenge.

The Pacific Institute is dedicated to protecting our natural world, encouraging sustainable development, and improving global security. Founded in 1987 and based in Oakland, California, the Institute provides independent research and policy analysis on issues at the intersection of development, environment, and security and aims to find real-world solutions to problems like water shortages, habitat destruction, global warming, and environmental injustice. The Pacific Institute conducts research, publishes reports, recommends solutions, and works with decision-makers, advocacy groups, and the public to change policy.

The Institute for Environmental Research and Education undertakes and disseminates comprehensive, fact-based research for use in the development of responsible environmental policy, programs, and decisions. The American Center for Life Cycle Assessment, the professional society for LCA in the United States, is its flagship program.

UNEP established the WaFNE Project in order to enhance water efficiency and water quality management through the refinement and pilot testing of several existing water accounting methods and supporting management tools. This project will encourage convergence of practice and compatibility among these methods. This $4 million project—established in March 2009—will be implemented over the course of three years with supporting partners including the UN Global Compact/CEO Water Mandate, Stockholm International Water Institute, Water Footprint Network, Society of Environmental Toxicology and Chemistry, World Business Council for Sustainable Development, World Economic Forum, International Water Association, National Cleaner Production Centre Network, UNESCO, and the UN-Water Secretariat. In addition to the stocktaking exercise, this WaFNE Project will:

- Map and refine methodologies and related management tools for the water footprint and water neutrality concepts;
- Build capacity and raise awareness among the public and private sectors in order to apply water accounting and neutrality concepts on a greater scale and with greater consistency,
- Demonstrate the applicability of harmonized concepts in enhancing water efficiency and improving water quality in water-intensive industries and water-stressed regions.

Some of the key outputs from this project will include: methodologies and tools for water accounting, dialogue platforms at the global and local level, a capacity platform with online knowledge management and guidance materials for water accounting methods, country-level pilot testing of methods, and awareness raising activities. The pilot testing will look at the implementing of corporate water accounting methods—in possibly six countries spanning multiple continents and at least four industry sectors.

As an initial step to the WaFNE Project, UNEP has commissioned a stocktaking exercise of existing methodologies and supporting tools for corporate water accounting. The findings of this stocktaking exercise are the subject of this report.

I. Introduction

PROBLEM STATEMENT

Water as a natural resource is facing many challenges at the local, regional, and global levels. Human water use is increasingly having negative impacts on human health, economic growth, the environment, and geopolitical stability. Rising demands for fresh water stem from a variety of factors, including population growth; industrial activities; increasing standards of living, particularly in emerging economies; and the effects of climate change. Current patterns of human water use are unsustainable; 5-to-25 percent of global freshwater use exceeds long-term accessible supplies, requiring overdraft of groundwater supplies or engineered water transfers (Millennium Ecosystem Assessment 2005). In specific regions, such as North Africa and the Middle East, up to one-third of all water use is unsustainable (Millennium Ecosystem Assessment 2005). Additional water stress is projected in Asia, which supports more than half the world's population with only 36% of the world's freshwater resources. If current trends continue, 1.8 billion people will be living in countries or regions with water scarcity by 2025, and two-thirds of the world population could be subject to water stress (UN News Centre 2009).

In recent years, concerns of growing water scarcity, lack of access to water to meet basic human needs, damaged ecosystems, human health issues, and the implications of climate change on the hydrologic cycle have brought water to the forefront as a strategic concern for companies around the world. Companies are realizing they are no longer able to easily access relatively cheap and clean water and that they must more closely consider limited supplies and the implications of their water use and discharge on watersheds, ecosystems, and communities. Further, pronounced water scarcity in key geographic regions, along with heightened expectations among important stakeholders including consumers and investors, has created a compelling business case for companies to actively pursue corporate water stewardship as a strategy that drives down water-related impacts and the subsequent business risks.

Companies' ability to measure and account for their water use and wastewater discharges throughout the value chain is a critical component in their risk assessment and mitigation efforts, as well as their broader ambitions to become responsible water stewards. Effective water accounting allows companies to determine the impacts of their direct and indirect water use and discharges on communities and ecosystems, evaluate material water-related risks, track the effects of changes in their water management practices, and credibly report their trends and impacts to key stakeholders. Water accounting also allows consumers, civil society groups, and the investment community to compare different companies' water risks and impacts in order to inform their actions and decision making. In sum, the ability to effectively account for corporate water use and impacts is essential in helping companies drive improvement and become aligned with external stakeholders' expectations, as well as their efforts to advance sustainable water management.

However, collecting and disseminating meaningful water-related information is a complicated and difficult undertaking. As this analysis will demonstrate, corporate water accounting methods and tools have been under development for the past decade, yet there is near universal agreement that current methods—though a good start—are inadequate and need to be refined.

PROJECT BACKGROUND

Research objectives

In response to this desire for improved corporate water accounting, several methods and supporting tools have emerged. The different origins, functionality, and evolving applications of the various approaches are currently poorly understood by stakeholders. There is a perceived need among businesses, civil society, and academia alike to elucidate the relation of these methods and tools to one another in order to help companies determine which approaches are best suited for particular applications. Improved clarity should also minimize duplication of efforts and promote coordination among the initiatives developing such methodologies.

This stocktaking exercise, a joint effort of UNEP and the CEO Water Mandate, will fulfill the need to clarify commonalities and differences among existing and emerging water accounting methodologies and tools being used in the private sector. Specifically, this report is intended to:

- Elucidate commonalities and differences among emerging methods and practice;
- Identify gaps and challenges;
- Suggest where accounting methods might benefit from harmonization and increased field testing.

Though this analysis will cover a number of water accounting methods and tools of relevance to businesses, it will emphasize perhaps the two most significant methods: 1) water footprinting (as managed by the Water Footprint Network) and 2) emerging water-related practice in the field of Life Cycle Assessment.

The authors note that the term "water footprinting" in and of itself is the source of confusion in this fast-evolving field and that it is currently being used to mean different things in various settings and arenas. The term "water footprint" was coined almost a decade ago by Professor A.Y Hoekstra of the University of Twente and refers to a specific methodology for water-use measurement. Since that time a community of practice has emerged that has built on Hoekstra's methodology. In the last couple of years the term has increasingly been used metaphorically by laypeople broadly referring to the concept of water accounting. There is seldom a formal definition associated with this lay usage of the term, and indeed, it is likely the concept is understood differently depending on the circumstance and individual user. Because of the lack of a formal definition, the authors have given little weight to this vague use of the term in common vernacular. In that same time span, the term has also entered the lexicon of Life Cycle Assessment (LCA) practitioners who have had a newfound interest in water. In this LCA context, the term is often used similarly to the term "carbon footprinting," insofar as it includes the characterization of water-use volumes according to local or regional context.

Nonetheless, for sake of clarity, unless otherwise specified, the term "water footprint" will be used in this report only in reference to the formal methodology developed by Hoekstra and currently managed by the Water Footprint Network (see page 11), as this is the longest-standing use of the term. That said, the way in which this term is used and understood by water accounting practitioners, water resource managers, and the general public in the future is still to be determined. The authors have no judgment on the most appropriate use of this term, but note the urgent need for experts and practitioners in both the LCA and WFN communities to come together to derive a shared understanding of this concept.

In addition to water footprinting and LCA, this analysis examines in lesser detail the WBCSD Global Water Tool and GEMI's on-line water sustainability tools. It also provides a cursory comparison of the ecological and carbon footprinting methods, particularly as they relate to corporate water accounting. Metrics such as those in the Global Reporting Initiative's G3 Guidelines and Carbon Disclosure Project's Water Disclosure Information Request may be an important starting point for communicating corporate water accounting results to external audiences. However, as they do not provide methodologies or tools through which to measure or assess water use (but rather a framework and indicators through which to report those types of measurements), they are not included among the accounting methodologies assessed in this report.

This study does not offer specific recommendations for the advancement of each method, but rather provides general comparisons that will help stakeholders to identify the best prospective applications for each method and support the developers of these methods to work in a more coordinated and integrated fashion.

Research methodology

The project's research methodology included: a review of current literature; interviews with numerous academics, industry representatives and practitioners; attendance at relevant water accounting gatherings; and conversations with various organizations working in the field. It emphasized an iterative and inclusive data collection and analytical process, whereby key stakeholders were engaged throughout the project to help develop the project work plan, the methodological approach, and report drafting. This engagement was done primarily through a Research Advisory Committee (RAC) which included stakeholders from the private sector (including numerous CEO Water Mandate endorsers); civil society organizations;

academia; the standards-setting community; as well as representatives from the Water Footprint Network and the LCA community. A prior iteration of this study was sent out for public comment from November 16 to December 11, 2009 and was discussed at a workshop in Paris on November 23-24, 2009 organized by UNEP, during which experts were encouraged to provide feedback and debate the contents of the draft and other components of the broader UNEP WaFNE Project.

The methods and tools explored in this analysis were selected based on the degree to which they are publically available and specifically designed to account for water use and discharge, as well as their applicability to a wide variety of geographic locations and industry sectors. In the process of selecting methods to be analyzed, we discovered a number of water accounting methods that are regionally/nationally-specific, industry-sector specific, or proprietary. Though these methods and tools were not included in our analysis, we have provided of brief summary of some of them in Appendix B. In addition, the International Organization for Standardization (ISO) is currently developing a standard for water accounting that is highly relevant to this research (not included because it is in early stages of development).

The four main methods/tools that serve as the focus of our analysis—Water Footprinting, Life Cycle Assessment, the WBCSD Water Tool, and GEMI Water Sustainability Planner/Tool—were assessed using a number of criteria designed to be broadly applicable to all relevant water accounting methods. They informed the development of the analysis, but not necessarily the structure of the final report due to their inherently inter-related and overlapping nature. These criteria are as follows:

Purpose, objectives, and applicability:

- For what internal and external purposes is the method or tool intended?
- What are the questions companies are trying to answer with this method?
- To what ends can companies currently use this method effectively?
- What is the level of maturity and market acceptance of the method? What components of the method are currently under development and not yet operational or effective?

Calculations, methods, and outputs

- What broad types of data and information does this method intend to gather/assess?
- How does the method divide/categorize data and information contained in the final product?

Water quality/Industrial effluent

- What broad approach to accounting for water quality does this method/tool take?
- What specific water quality-related data and information is (and is not) accounted for in this approach?

Assessment of impacts to watersheds, ecosystems, and communities

- What criteria does each method use to measure local water resource context data and information?
- What is the method able (and not able) to communicate and quantify through its approach to impacts?

Assessment of water-related business risks and opportunities

- How, if at all, does the method account for and quantify business risks and opportunities associated with water-related impacts on watersheds, ecosystems, and communities?
- Does the method recommend specific actions to reduce water-related business risks?

This analysis does not delve deeply into technical aspects of any of the methods, but rather provides a general overview of the concepts that underpin them. It uses the ten stakeholder interviews conducted as the basis for assertions of most and least effective applications of these methodologies and tools.

CORPORATE WATER ACCOUNTING IN CONTEXT

Comprehensive corporate water accounting requires a number of different types of data and assessments in order to derive meaningful information. However, in order to contribute to improved corporate management practices and ultimately the sustainable management of water resources, corporate water accounting must also work in unity with a number of other components. While companies have direct control over some of these aspects, they have limited ability to influence others. That said, understanding this broader context—and how water accounting fits into it—is essential for companies seeking to reduce and mitigate water-related risks. Key components of this broader framework are:

External Water Resource Context and Data: A foundational component of this framework is the real-world characteristics and conditions of the watersheds, ecosystems, communities, government, and economy in which businesses exist.

Corporate Water Accounting: Accounting allows companies to measure and understand the water systems in which their business and suppliers operate, as well as the volume, timing, location, and impacts of their water use and discharge. This provides a basis from which to plan strategically, assess management practices, track performance over time, and communicate with stakeholders.

Public Disclosure and Stakeholder Feedback: Once corporate water use and impacts are accounted for, companies disclose quantitative and qualitative information to affected communities, investors, consumers, civil society, and other stakeholders. This allows stakeholders to evaluate companies' approaches to reducing impacts and addressing risk and to hold companies accountable for their management practices. Stakeholder feedback in turn helps companies identify and prioritize material issues and improve the processes through which they mitigate negative impacts and thereby address water-related business risks.

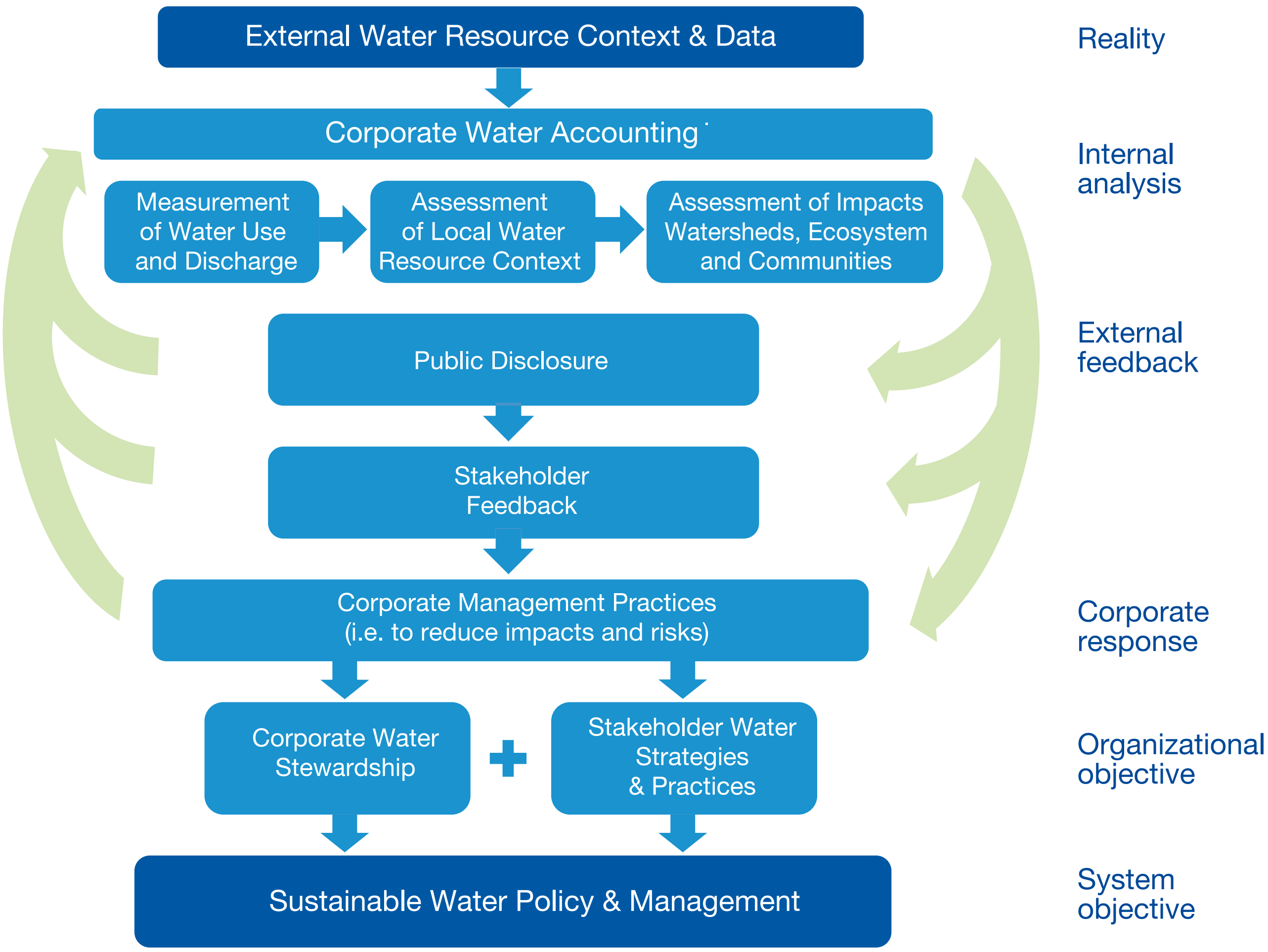
Corporate Water Management and Stewardship: Accounting is intended to inform more responsible and efficient corporate water management practices. Once these management responses successfully address negative impacts on ecosystems and communities, the company may be considered a good steward of water resources.

Stakeholder Water Practices and Strategies: Corporate water stewardship alone cannot ensure sustainable water management within a region. This component is comprised of all the players (i.e., communities, policymakers, water managers, and other stakeholders) that must take action in order to move toward sustainable water management of a locality or watershed.

Sustainable Water Management: When companies and other stakeholders in a watershed are effectively and collectively implementing responsible water practices and managers prioritize needs (i.e., industrial, agricultural, municipal, and environmental) based on resource availability and account for long-term risks (e.g., population growth and climate change), the system is positioned to reach a sustainable state—the overarching goal of corporate water stewardship and water management in general.

While the primary focus of this analysis is on the water accounting component of this framework, we will touch upon some of these components described above. Specifically, we will consider the degree to which current water accounting methods and tools are positioned to address external stakeholders' water-related information needs. We will also touch upon the emergence of corporate water stewardship approaches targeted at addressing water impacts, and evaluate the state of water resource data that currently hampers the evolution of water accounting practice.

Figure 1: The role of water accounting in advancing sustainable water management



II. Understanding Water Accounting Needs and Mechanisms

Water accounting—as well as companies' need for and use of it—has evolved significantly over time. In exploring these needs and their evolution in recent years, we summarize when and for what reasons companies are seeking to use existing methods and tools, along with the questions they are asking with regard to their corporate water use/discharge and the resulting impacts and business risks. This review is divided into four inter-related categories, which will also serve as the thematic structure used throughout the latter sections of the report:

1. Operational efficiency, product eco-design, sustainable manufacturing (Section II)
2. Water risk assessment/identification (Section IV)
3. Managing water impacts and water stewardship response (Sections V & VI)
4. Communicating water risk/performance with stakeholders (Section VII)

These categories are somewhat artificial and have a great deal of overlap, but do represent the broad types of applications for which these methods and tools are used, as well as the evolution of corporate water accounting over time. These areas of interest to companies are influenced by a number of factors, including the pursuit of operational efficiencies, strategic planning, brand management/corporate reputation, and corporate ethics/philanthropy. However, at their root, they are all driven by the desire to identify and reduce water-related business risk (and seize opportunities), whether that be through building competitive advantage, ensuring long-term operational viability, or maintaining and/or improving social license to operate. Because understanding and mitigating the interrelated issues of water risk and impact is a core driver for emerging water accounting methods and tools, they are explored in detail in Sections IV to VI.

It should be noted that companies' various accounting needs (e.g. product-level, company-wide, and impact assessments) all require different types and amounts of data. Product-level and company-wide assessments require internal production data from many different watersheds around the world. They can also utilize watershed data, but this is typically only cursory data taken from global indexes. Due to the variety of potentially impacted watersheds, these assessments do not attempt to comprehensively address complex local issues, but rather to drive sustainable production and consumption practices (and in doing so reduce the pressure on freshwater systems). Place-based assessments look specifically at water use in one (or a few) watersheds in order to gain a better understanding of that system. They can be used to assess a company's impacts on that watershed as well as the business risks created by external conditions. These assessments rely on watershed data regarding water stress, pollution, environmental flows, access to water services, etc.

OPERATIONAL EFFICIENCY, PRODUCT ECO-DESIGN, SUSTAINABLE MANUFACTURING

The most basic (and well-developed) sphere of corporate water accounting relates to internal management and decision-making, which in this report encompasses issues such as operational efficiency, product eco-design, and sustainable manufacturing. As a starting point, companies often measure the amount of water they use and discharge directly at the facilities they own or operate. This practice has been demanded by law and regulations in many developed countries since at least the 1970s and is often carried over to facilities in less-developed countries. These measurements have been largely driven by a desire to maximize operational efficiencies (e.g., decrease the amount of water-related infrastructure needed and to reduce costs and/or energy needed for production processes and/or wastewater treatment). To this end, companies typically look at the efficiency of their direct operations in terms of volume of water withdrawn/consumed and amount and quality of wastewater discharged per unit of production or unit of sales. Companies are increasingly applying these same measurements to their key suppliers in order to better assess the water requirements for products and operations throughout the value chain. Eventually, such measurements can be used as the basis for operational "hotspotting," where companies can identify the components of their value chain that use and discharge the most water.

Key questions companies ask with regard to accounting for their water use/discharge for internal management purposes include:

- How much water do we use in all of our owned/operated facilities?
- How efficiently is this water use normalized to production?
- How much wastewater is discharged to the natural environment and of what quality is it when it leaves the facility? What are the major contaminants released?
- How much water do my suppliers use? How efficiently? How much wastewater do they discharge and of what quality?
- In which segments of my value chain does my company use/discharge the most water?

Because approaches to internal water measurement typically vary depending on the company and/or are proprietary, we do not explore this area of water accounting in much detail, nor do we analyze the topic in a standalone section in this report. That said, the authors recognize that such internal water measurement typically provides the foundation (i.e., inventory) for corporate water accounting methods such as WF and LCA that we review in detail in this assessment. Likewise, we acknowledge that some aspects of improved operational efficiencies and sustainable manufacturing are informed by real or perceived business risks and a science-based understanding of the actual environmental and social impacts associated with the company's water use/discharge. The discussions of risk and impact assessment as a management decision support tool are included in Sections V and VI. Lastly, to the degree to which companies communicate commonly used metrics associated with their water use/discharge (e.g., GRI reporting), we address such water measurement in Section VII.

WATER RISK ASSESSMENT/ IDENTIFICATION (E.G., "HOTSPOTTING")

As global freshwater scarcity has become more pronounced and as the supply chains of most major companies have spread across the globe, concerns have mounted among companies regarding their continued access to water resources. Further, companies recognize that their water practices might be negatively impacting communities or ecosystems, thus creating business risks. However, the simple measurement of corporate water use and discharge does not speak to a company's water risks or impacts per se. Water risks depend on the highly variable local context (i.e., watersheds, ecosystems, communities, and water users) in which the company and its suppliers operate.

Understanding water-related business risk means considering the local context in which companies find themselves. In the 1980s and 90s, companies first started assessing the status of water resources in locations of key operations, though these assessments typically only took into account physical water availability (i.e., the amount of natural water available on an annual average basis, perhaps normalized to population). However, while this broad measure of physical supply can provide useful contextual information, it is widely considered inadequate as an approximation of risk.

More holistic examinations of local context (i.e., watershed status) evaluate factors such as the percent of available water used for human purposes, the amount of water allocated to meet in-stream environmental flow needs, the adequacy of local water management and governance capacity, and the ability of nearby communities to access (and afford) water services, among other things. These "local context" factors ultimately lead to a better understanding of a watershed's relative water abundance or scarcity, as well as the company's water-related risks. By using geographic "hot-spotting" techniques to identify facilities located in watersheds considered to be water stressed, companies can begin to prioritize the locations in which to invest in operational efficiencies, contingency planning, policy engagement, community outreach, or other risk-mitigation measures.

Companies manage business risks through a number of different avenues depending on the nature of their impacts, the nature of their operations, and the watershed in which they are located. However, there are a few broad stewardship activities that may lessen impacts and drive down many types of risks. For instance, improving operational efficiency (using less water or re-using it or discharging cleaner water per unit production) decreases demand for water supplies and therefore alleviates water stress (and corollary scarcity risks) and/or reduces production costs. This efficiency may also help companies assure their continued water use by providing sufficient economic value per unit water so as to justify that allocation by policy makers. They also work with their suppliers to ensure that their goods are responsibly produced throughout their life cycle. If the most pressing risks are posed by external conditions, companies may respond by engaging with communities and public water managers within their region in order to simultaneously improve their efficient and continued access to water resources and build trust-based relationships that may help prevent future allocation debates and/or garner goodwill and positive reputation as a responsible business.

Some of the key questions companies are asking with regard to assessing water business risks associated with their operations include:

- Which of my facilities are located in water-stressed regions (including physical, economic, and social scarcity)?
- What is the nature of our water use and discharge (and possible corollary business risks) in various locations?
- What percent of this watershed's available water do my facilities use?
- What percent of the available water in this particular watershed is used for human purposes and what are the allocations among sectors?
- In which locations are water governance and management capacity a concern?
- How secure/reliable is our legal access to water in those locations?
- In which locations is there a high potential for reputational risk due to insufficient environmental flows or inadequate access to water services among local communities?
- How can I expect my exposure to water-related risks to change due to population growth, climate change, economic development, and other factors?

MANAGING WATER IMPACTS/WATER STEWARDSHIP RESPONSE

It is widely accepted that volumetric measures of water use alone are not an adequate indicator of a company's water-related business risks or social and environmental "impacts" as they do not consider the aforementioned local water context. The necessary, yet by far most complex component, of corporate water accounting is the assessment of the actual impacts to watersheds, ecosystems, and communities caused by corporate water use and discharge. In this context, "impacts" refer to the extent to which the volume of water used/discharged by a company in a specific watershed actually affects the availability of that water for other uses (e.g., meeting basic human needs or in-stream flows) or harms human health or ecosystems in any other way. Corporate water use can potentially have positive impacts as well (e.g., improving water quality or recharging aquifers), however most water accounting methods tend to focus on negative impacts of water use.

Identifying and measuring water-related impacts (both quantitatively and qualitatively) is key to enabling companies to make effective management decisions based on accurate comparisons of water use in different watersheds, across different products, or in different components of the value chain or product life cycle. It is also crucial to understanding which facilities or products pose the greatest threat to nearby communities and ecosystems, and consequently present the most concerning business risks that must be managed.

Current methods for assessing environmental impacts (e.g. effect on freshwater biodiversity or environment flows) are considerably more developed than methods for social impacts (e.g. effect on incidence of disease or human access to water). However, social impacts are equally important as environmental impacts (if not more so) with respect to business risks. Even in water-rich areas, companies are likely to be exposed to reputational and regulatory risks if they operate in an area where there is insufficient access to water services or if their industrial effluent causes human health problems.

Some of the key questions companies ask in order to manage their water impacts include:

- Which of my facilities or products pose the greatest social and environmental impacts?
- Which components of my value chain or product life cycle result in the greatest impacts?
- How do my operations in a specific watershed affect ecosystem functions and/or in-stream flows?
- How do my operations in a specific watershed affect the ability of communities to access or afford adequate water services?
- How do my operations in a specific watershed affect human health?
- How might these various impacts expose us to business risks?

Communicating water risk/performance with stakeholders

Once an internal assessment of corporate water use and related risks/impacts is completed, companies are increasingly disclosing this information (or part thereof) to their stakeholders and the public at large. Such reporting allows companies to be transparent and accountable regarding their water use and wastewater discharge, and also allows various stakeholders to track and provide feedback on corporate practices and performance. In Section VII we discuss the links among various water accounting methods/tools and corporate water disclosure.

Some of the key questions companies ask in regard to their disclosure of water-related information include:

- Are there well-established/harmonized metrics with which consumers, investors, and affected communities expect us to report our water-related data?
- What accounting methods are easily understood by non-technical audiences?
- What kind of information is most helpful for consumers hoping to make an informed purchasing decision? Do available methods provide this?
- What kind of information is most helpful for investors looking to assess water-related risk and/or to put money in an "ethical" company? Do available methods provide this?
- What kind of information is most helpful in reassuring potential affected communities and therefore supporting our social license to operate? Do available methods provide this?

III. Origins, Objectives, and Structure of Methods and Tools

Current water accounting methods and tools all have different histories, intended objectives, and outputs. This section will explicate these origins and core functions in order to shed light on the circumstances for which various methods and tools may (or may not) be appropriate and effective for purposes of corporate water accounting. In doing so, we attempt to assess the scope of the method/tool and its intended objectives and subjects/audiences, as well as the information captured in the end product/analysis.

Water footprinting (as managed by the Water Footprint Network)

Origins

Water footprinting—a methodology introduced in 2002 and developed primarily by researchers at the University of Twente (Netherlands)—measures the total annual volume of freshwater used to produce the goods and services consumed by any well-defined group of consumers, including a family, village, city, province, state, nation, and more recently, a business or its products. Water footprints (WFs) are intended to allow these entities to better understand their relationship with watersheds, make informed management decisions, and spread awareness of water challenges worldwide. Throughout this decade, the water footprinting method has been refined, beginning to incorporate ways to achieve more reliable and spatially and temporally explicit data and to better account for water quality and impacts, among other things.

Water footprinting was originally developed as an accounting tool for water resources management (WRM) and is currently well-established as a leading methodology in this field. WRM accounting to this day remains one of the primary roles of water footprinting, with the WF measure allowing policymakers, planners, and managers to map various water uses in a system (e.g. agricultural, municipal, industrial), as well as the amount of water used by the community, country, region, etc. to produce the goods and services they consume. For WRM, the actual volume of water used is critical information as it allows decision-makers to, for instance, understand how water use relates to overall supply volumes; how water is allocated among users within their system (and if it is allocated equitably); which needs (e.g. environmental, basic human) are being met; and which water uses are providing the most economic value per unit volume. Armed with WFs, policymakers and water managers are better positioned to make water allocation and other decisions.

Water footprinting in the context of WRM was born out of and is underpinned by the concept of virtual water—the volume of water used to produce individual goods and services (most notably crops) throughout all stages of production. One critical aspect of virtual water is that it accounts for the water needed to make the goods and services that are imported into a system. Thus WFs in the WRM context account for virtual water trade through the notion of internal and external WFs, which track how much of a region's water resources are used for goods and services consumed in that area versus how much foreign water is used for those same purposes. The volume-focused virtual water concept (measured by means of the WF) has proven quite helpful for water managers and policymakers as they consider the merits of domestic food and/or industrial production versus importing (and/or not exporting) water-intensive goods, in conjunction with shifting water allocations to uses with more economic value in water-stressed areas.

Only in the last couple of years has the private sector begun to use WF to assess their direct and indirect water use, bringing with them the new questions and needs of the accounting method. A key distinction is that water footprinting for WRM focuses on providing information that helps water managers understand all volumetric needs (i.e., communities, ecosystems, businesses) and prioritize those needs in the face of scarcity based on societal, environmental, and economic values. In contrast, companies are typically concerned with the ability of available water supplies to meet their own needs and understanding their risks and impacts associated with the WF across multiple different watersheds. This is because of their desire to understand their indirect water use (i.e., the water embedded in their supply chains) and because of the global reach of most corporations' value chains.

Scope, structure, and outputs

Water footprinting focuses solely on providing a method for companies to measure their water use and discharge; within the context of the Water Footprint Network, the WF itself does not aim to assess the status of watersheds or water-related impacts per se. A WF captures the volume, location, and timing of water uses and discharges. WFs are divided into three separate components—the blue, green, and gray—all of which are expressed in terms of water volume. These components are meant to be considered both separately and together as a total WF (i.e., the sum of the blue, green, and gray water footprints). The three WF components are defined as follows:

Blue water – the volume of consumptive water use taken from surface waters and aquifers.

Green water – the volume of evaporative flows (found in soils rather than major bodies of water) used.

Gray water – the theoretical volume of water needed to dilute pollutants discharged to water bodies to the extent that they do not exceed minimum regulatory standards.

The green and blue components of a WF focus on consumptive water use (i.e., the volume of water removed from local water system by evaporation, inclusion in a product, water transfer, or otherwise). They do not include those uses of water that are eventually returned to the same system from which they are withdrawn (i.e., non-consumptive uses). To the degree to which non-consumptive water use is addressed, it is done within the gray water component.

A WF as described above is only one component of a larger water footprint assessment. A WF is purely a volumetric account of water appropriation. A broader WF assessment looks at the sustainability of that appropriation and steps that can be taken to make it more sustainable. A full water footprint assessment is divided into four stages:

1. Setting goals and scope
2. WF accounting (the traditional "water footprint")
3. WF sustainability assessment
4. WF response formulation

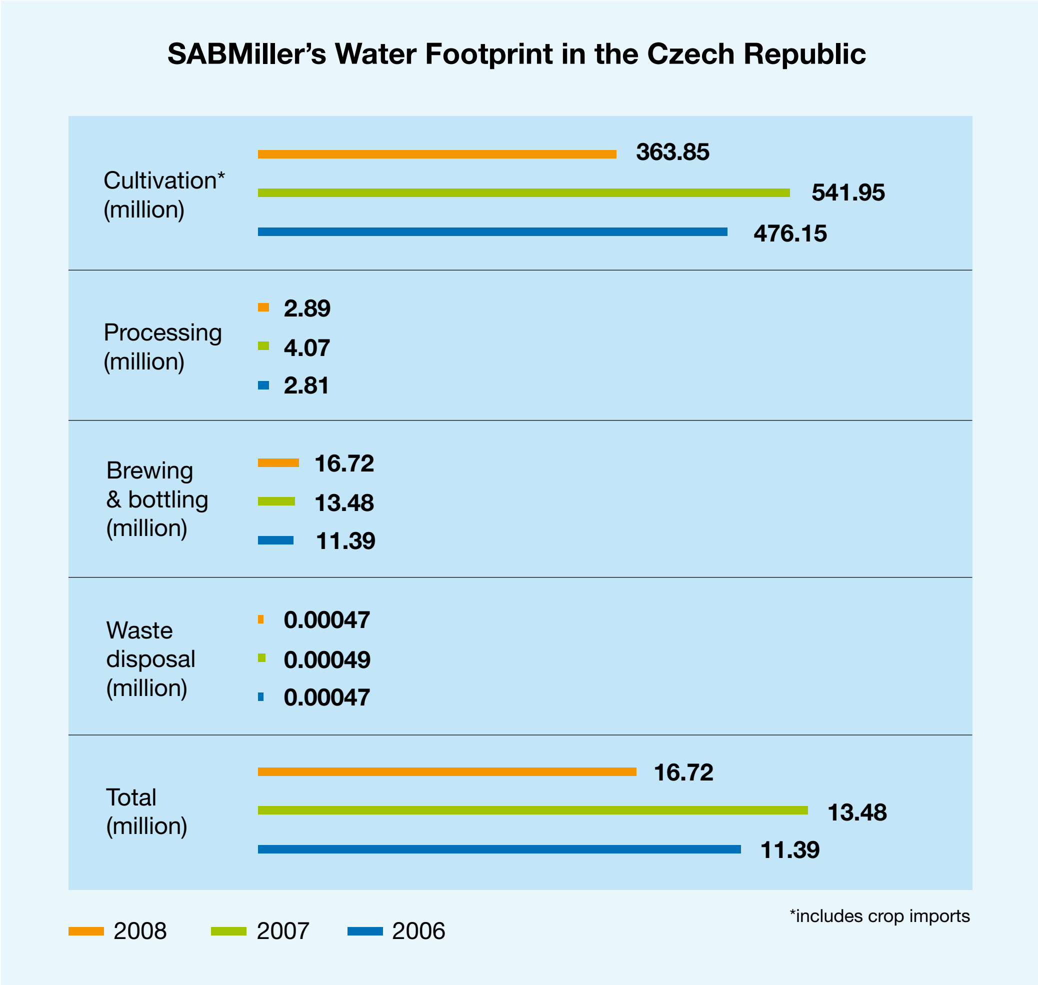
The first phase sets the boundaries of the assessment. The second phase is the traditional water footprint where water uses are measured by volume. The third phase is essentially an impact assessment where water use is compared with local water availability data. In the final stage, response options such as strategies, targets, or policies are formulated. The "water footprint" and "water footprint assessment" terminology is the source of some confusion. For the purpose of this report, "water footprint" refers solely to the second phase presented here. Current practice in corporate water accounting has in most cases consisted of only the first two stages. "Sustainability assessments" are important, but are not yet common practice.

Corporate WFs measure the total volume of water used directly and indirectly to run and support a business. They are typically scoped to focus at the company-wide or facility level but can also focus on specific products and their water use throughout a company's value chain (e.g. raw material production, manufacturing, distribution). Corporate WFs are meant to be divided between their operational and supply chain components; however, comprehensive assessments of water use in a company's supply chain through water footprinting are not widely practiced to date due to the difficulty in obtaining data for large supplier networks.

BOX 1: SABMILLER AND WATER FOOTPRINTING

In 2008 and 2009, SABMiller—a South Africa brewing company—conducted water footprints of its South African and Czech operations. These two locations were selected due to their large volume of product and because they are both in water stressed regions. This analysis allowed SABMiller to identify geographic locations and production stages with particularly high water use, and also to compare these very different supply chains to understand how their mitigation strategy might differ depending on location.

These two analyses demonstrated important differences in SABMiller's water use in different locations. The studies estimated that it takes 155 liters of water to produce one liter of beer in South Africa, while it takes only 45 liters to produce the same amount of beer in the Czech Republic. The analysis revealed that this discrepancy is not due primarily to different production efficiencies, but rather climatic differences, the amount of imported crops, and packaging. For instance, whereas the Czech operations import about 5% of their crops, the South Africa operations import 31% of their total crops mainly from the United States, Argentina, and Australia. Further, blue water comprised about 34% of water use in South Africa, but only 6% in the Czech Republic, which instead was heavily reliant upon green water for grain production. This does not ultimately change the total water footprint, but does have significant implications in terms of the impacts of that water use and potential risks due to competition and scarcity. The vast majority of water use (over 90%) in both locations occurred in the crop cultivation stage. Even within the individual countries, the study found significant regional differences. In the some parts of South Africa, barley and maize production relied on irrigation/blue water for 90% of their water consumption. In others, those same crops were grown using only green water.



These studies have helped shape SABMiller's sustainability strategy for the future. For instance, in South Africa, the company is piloting its "water neutral" concept in two regions identified as posing particular water-related risks. Furthermore, after identifying that agricultural water use is the greatest area of water intensity, the company has been looking into toolkits for sustainable agricultural practices and is employing agricultural extension workers to improve yield management and water efficiency.

Source: Water Footprinting: Identifying & Addressing Water Risks in the Value Chain. SABMiller and WWF-UK. August 2009.

LIFE CYCLE ASSESSMENT

Origins

Historically geared toward and used by the private sector, Life Cycle Assessment (LCA) is a systems analysis tool which was designed specifically to measure the environmental sustainability of products and services through all components of the value chain. LCA is an input-output tool, measuring resource use and emissions that can be allocated to a particular product. In addition to its use by the private sector, LCA has also been very successfully used as a national and even international policy tool, and is imbedded in many laws in the EU, Japan, Malaysia, Australia, and elsewhere. LCAs can be set to analyze environmental impacts at many different scales (e.g. watersheds, counties, or countries). Properly done, an LCA allows companies and other interested parties (including consumers) to make comparisons among products and services. LCA is a decision-support tool that has primarily been used for three kinds of decisions:

Engineering decisions for product/ process improvement: Also called design for environment or eco-efficient manufacturing, this allows companies to identify opportunities for environmental improvement/optimization and measure the improvement along the entire supply chain. With LCA practice, this is often linked to hotspot analysis or identifying which parts of the product life cycle have the greatest environmental impacts.

Policy decisions at the company or governmental level: This allows companies to develop a more rational and holistic view of the environmental impacts of their activities. In this context, economic input-output life cycle analysis—though actually not applied at the company level—has proven to be a very useful economy-wide tool, permitting one (typically government entities) to calculate estimates of the impacts of marginal production in the different economic sectors. Use of LCA in the context of national rulemaking is countenanced within the World Trade Organization as not creating a technical barrier to trade, providing that the relevant international standards are followed.

Environmental purchase and sales decisions: This occurs either as a support for environmental claims or as the supporting information for LCA-based ecolabels. Use of LCA in communicating environmental issues with external stakeholders is discussed in detail in Section VII. Environmentally preferable purchasing programs often make use of LCA as a decision-support tool.

Water and LCA

Hundreds of thousands of LCA studies have been published in the last 40 years. The field of agricultural LCA has been especially prolific, and several international conferences have been devoted to the LCA of foods. However, traditionally, water use has not been accounted for within this method in any sort of detailed or comprehensive fashion. If measured at all, water use has typically been accounted for strictly as an inventory of a product's total water withdrawal (rather than consumption) that is neither locally specific nor features any impact assessment. However, given companies' growing concerns over water scarcity in the last decade, the development of better ways of accounting for water use within LCA has become a priority. Further, consensus appears to have been reached among LCA practitioners on the importance of better differentiating between consumptive and non-consumptives water uses in LCA studies. Also recognized is the need to understand and specify the geographic location of water use, the sources of the water (e.g., lake/river, groundwater, rainwater) and whether those sources are renewable or non-renewable.

There is currently an abundance of research on water scarcity and life cycle impact assessment modeling of the resource, along with the health effects and ecosystem damage associated with water scarcity. LCA practitioners have put forward different ways of characterizing the impacts of water use, though these have varied from study to study. Some of the impact categories proposed in these methods include water sufficiency for different users, ecosystem quality, resource consumption, and human health, among others. LCA's approach to impact assessment is discussed in detail in Section V.

Scope, structure, and outputs

Unlike water footprinting, which focuses on a single environmental resource (i.e., water), LCA was designed as a method that enables cross-media evaluations and comparisons across many different types of environmental resources, emissions, and their impacts. Indeed, the ability to assess impacts across a range of environmental categories is LCA's core function and value. These analyses require a much more comprehensive process than the strict water-related measurements seen in water footprinting. LCAs are typically comprised of four basic stages:

1. **Goal and scope:** The goals and scope of study in relation to the intended application are specified. This includes establishing the boundaries of the system being assessed (i.e., determining what is being measured) and defining the functional unit of the product for the purpose of the study, a measure of the product or service being assessed.

1. **Life cycle inventory**: Environmental inputs and outputs (e.g., water use, GHG emissions) that may have subsequent impacts are measured. In respect to water, this is the stage where the volume; timing; type (i.e., stocks, flows); location of use; and the volume/mass of contaminants released to waterways (among other things) may be captured.

1. **Life cycle impact assessment:** The environmental inputs and outputs measured are translated into impacts (e.g., contribution to global warming, fresh water depletion, human health concerns). Emissions and resource uses from a variety of different sources are collected and assigned into their relevant impact categories, then characterized by the relevant impact factors developed through resource management and fate and transport models.

1. **Interpretation:** The final stage further translates the quantification of impacts determined in the previous stage into meaningful conclusions and recommendations to improve the environmental performance of the product or service.

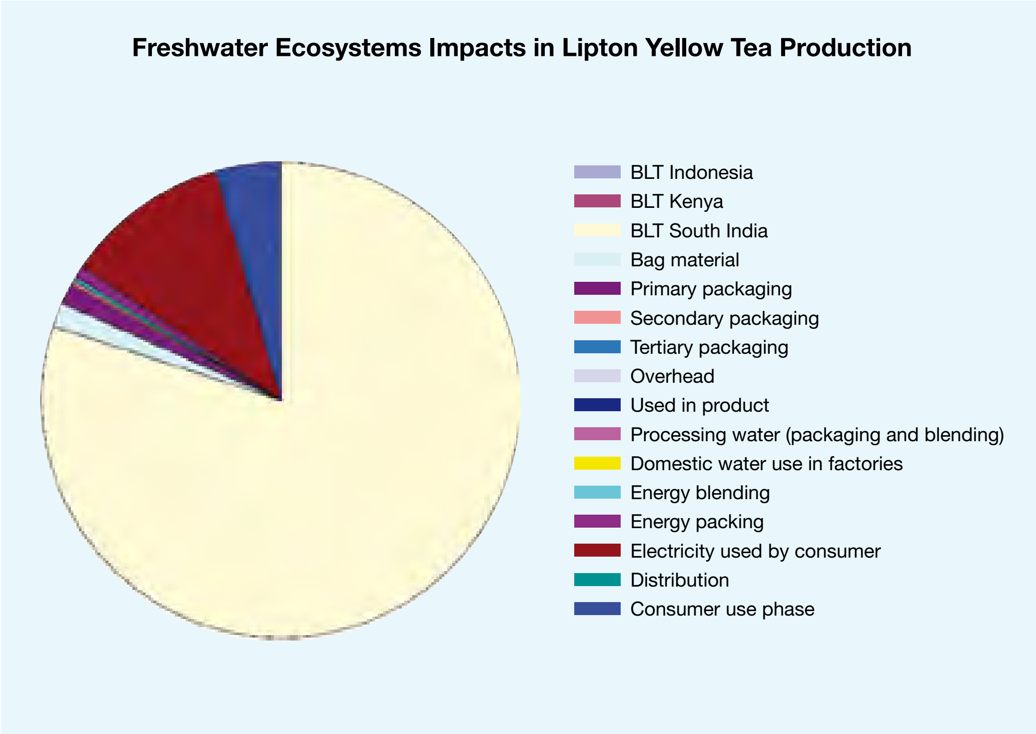
As discussed, LCA provides information on different types of environmental activities and different impact categories which those flows can affect. This allows LCA to quantify and compare the multiple types of impacts caused by one type of use or emission, as well as the various resource uses or emissions that contribute to one type of impact (e.g., the various business activities that contribute to eutrophication of water bodies). Typically, life cycle inventory data reflects the volume of water used at a given unit process. The challenge for evaluating the impact of water use is that often one does not know where that unit process occurs.

BOX 2: UNILEVER, WATER FOOTPRINTING, AND LCA

Unilever recently conducted two case studies that piloted the accounting and impact assessment components of both water footprinting and LCA for two of its products: tea and margarine. It aimed to compare the two accounting approaches in terms of functionality, determine how the results can be practically implemented, test impact assessment methods, and contribute to methods development.

The WF study measured the blue, green, and gray water footprints, while separating them into supply chain and operational components. Though impact assessment is typically not included in WFs, this study attempted to assess impacts by mapping areas of significant water use on a water stress index (i.e., ratio of water withdrawals to water availability) map. This was not used to calculate impact indexes (or “scores”) but rather simply to identify hotspots.

The LCA study used a variety of different data inputs. It used WF calculations (i.e., evaporative uses of blue and green water) as the basis for its crop water use measurements, Unilever data as the basis for its manufacture and end use phases measurements, and databases from the Ecoinvent Centre for data on background processes. The main differences between the two methods for this stage were that WF does not include energy-related water use and LCA tended to overestimate certain water uses because it looked at abstracted water instead of consumed water. Like the WF study, the LCA study used a water stress index using the ratio of withdrawals to availability to determine impacts. However, unlike the WF study, the LCA study calculated impacts in order to get a quantified assessment of impacts across different production processes. The LCA study also included an assessment of impacts on eutrophication and ecotoxicity resulting from pollution caused by the products. Despite some differences, Unilever found that the methods were ultimately quite similar in the hotspots they identified.



Source: Assessing Water Impacts of Tea and Margarine with a Water Footprint / LCA Approach: Pilot Study in Unilever. Unilever and Water Footprint Network. September-October 2009.

WBCSD GLOBAL WATER TOOL

Origin, objectives, and scope

Unlike water footprinting and LCA, which are comprehensive methodologies for assessing water use and discharge, the WBCSD Global Water Tool[1] is an implementation platform. Launched in 2007 and developed by WBCSD member CH2M HILL, the Global Water Tool is a free online module that aims to couple corporate water use, discharge, and facility information input with watershed and country-level data. It compiles such information to evaluate a strict measurement of water use in the context of local water availability (based on the Tool's watershed and country-level databases). This process is intended to allow companies to assess and communicate their water use and risks relative to water availability in their global operations and supply chains. The WBCSD estimates that more than 300 companies worldwide have used the Tool since its launch.

Structure and outputs

The Tool has been developed to provide a number of distinct outputs that, while pertaining to related issues (i.e., corporate water use and management), are not aggregated and do not build on each other in the way water footprints and LCA do. A full use of the Global Water Tool produces the following outputs:

- **Output GRI Indicators:** GRI Indicators—total water withdrawals (Indicator EN8); water recycled/reused (Indicator EN10); and total water discharge (Indicator EN21)—are calculated for each site, country, region, and total.
- **Output Country Data:** Displays site water usage information and connects country water and sanitation availability for each site.
- **Output Watershed Data:** Displays site water usage information and connects watershed information for each site.

[1] To access the WBCSD Global Water Tool, go to: www.wbcsd.org/web/watertool.htm

- **Combined Country and Watershed Metrics:** Combines site information and external country data and reports metrics for the company's portfolio of operations through graphs. For example, the Tool produces a graph that shows the number of facilities, workers, and suppliers a company has in areas of extreme scarcity, water-stressed areas, water-rich areas, etc.
- **Visualization of Data:** Displays site locations compared to local water context in form of maps and through Google Earth.

GEMI WATER SUSTAINABILITY PLANNER AND TOOL

The Global Environmental Management Initiative (GEMI), a collection of dozens of mostly North American-headquartered companies working toward more responsible corporate environmental stewardship, has developed two tools to advance corporate understanding of water issues. Released in 2002, the Water Sustainability Tool[2] is an online tool that helps organizations create a water strategy. It assesses a company's relationship to water, identifies associated risks and describes the business case for action, and helps address companies' specific needs and circumstances. It features five modules:

1. Water Use, Impact, and Source Assessment
2. Business Risk Assessment
3. Business Opportunity Assessment
4. Strategic Direction and Goal Setting
5. Strategy Development and Implementation

The Tool does not provide a method or calculator to measure or quantify water use, impacts, and risks, but rather introduces a number of questions on these topics to facilitate companies' understanding of various water sustainability issues. These questions act as the basis for guidance on goal setting and the development of strategic plans.

The GEMI Water Sustainability Planner[3]—an online tool released in 2007—focuses on the needs of a facility-level user rather than the company as a whole. It helps facility personnel to better understand the facility's dependence on water and the status of the local watershed (including local social and environmental considerations) and to identify its specific challenges and opportunities. The Planner is divided into three modules:

1. Facility Water Use and Impact Assessment Program
2. Water Management Risk Questionnaire
3. Case Examples and Reference Links

It uses input from the facility to give a broad assessment of risks regarding the local watershed, supply reliability, efficiency, compliance with regulations, supply economics, and social context. As with GEMI's Water Sustainability Tool, the Planner does not provide quantitative data but rather qualitative guidance on risks and identification of some of the most pressing issues.

From the perspective of the researchers, both GEMI tools are perhaps best oriented to companies and facilities that are just beginning to understand how water issues affect nearby ecosystems and communities, as well as their own business risks. They can be used to get a broad assessment of some pertinent questions, but provide no quantitative information with which to compare different water uses, products, or facilities. As such, they are perhaps less useful for companies that are seeking a comprehensive assessment of different water uses and impacts in order to assess hotspots, drive product development, or identify specific long-term water strategies.

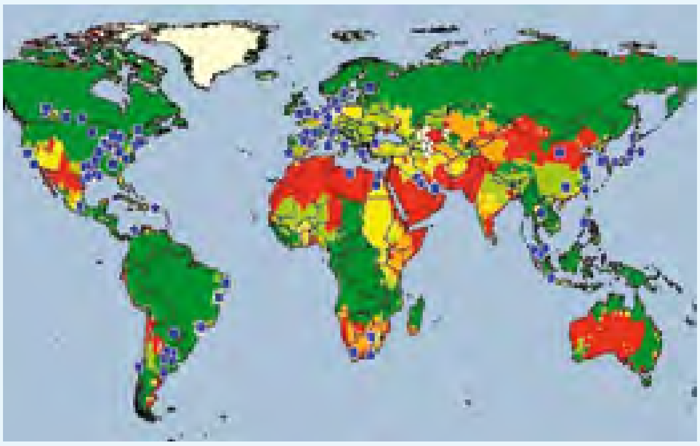
[2] To access the GEMI Water Sustainability Tool, go to: www.gemi.org/water/
[3] To access the GEMI Water Sustainability Planner, go to: www.gemi.org/waterplanner/

BOX 3: DOW CHEMICAL'S USE OF THE WBCSD & GEMI ONLINE TOOLS

In 2006, the Dow Chemical Company used the WBCSD Global Water Tool and GEMI Water Sustainably Planner as the bases for a water-related risk assessment for all of its facilities worldwide. At the time, Dow was experiencing greater infrastructure costs and other impacts from drought in many of its facilities. However, the resources and time necessary to individually assess the situation at each of its roughly 160 facilities worldwide were prohibitive. As a result, they decided to use the available, open-source tools from WBCSD and GEMI to guide their analysis.

Dow used the WBCSD Tool's Google-powered "global address look-up capability" to map all of these sites and overlay them with water stress information, both current and predictions for 2025. This allowed them to quickly and efficiently identify its facilities that were at greatest risk of water stress and associated problems. Using the Tool, Dow was able to complete this phase in a number of weeks.

Dow's Use of the WBCSD Global Water Tool to Identify Water Risk Hotspots



After mapping all of its sites, Dow gathered water use data for all the sites which it determined to be at risk of water stress. As part of the data collection process, Dow sent the risk survey found in the GEMI Water Sustainably Planner to experts at each of the targeted sites. The Planner provided conceptual thinking regarding possible drivers and local issues that inform water stress and resource planning. It also generated risk factor scores for each of the following areas: Watershed, Supply Reliability, Social Context, Compliance, Efficiency, and Supply Economics. These scores were used to create risk profiles for each site that could be used to determine appropriate mitigation strategies.

Sources: (1) Use of the WBCSD Global Water Tool to Assess Global Water Supply Risk and Gain Valuable Perspective. Water Environment Foundation WEFTEC 2008 Proceedings. October 2008;
(2) Personal correspondence: Van De Wijs, Peter Paul. Dow Chemical Company. Global Government Affairs and Public Policy Expertise Leader. January 19, 2010.

FINANCIAL AND PERSONNEL REQUIREMENTS FOR WATER ACCOUNTING METHODS AND TOOLS

Corporate water accounting assessments typically require notable amounts of company time and money to provide meaningful results. The resources needed vary significantly depending on the scope of study, the type of data used, the size of the company, and the type of analysis conducted (e.g. water footprint or LCA). Acknowledging this large variability, below we provide general estimates of the company resources needed for each of the main methods and tools discussed in this report. This information is based on input provided by developers of these methods and tools and companies who have used them.

Water Footprinting

The time and financial requirements for water footprint assessments vary depending on whether companies' water use is measured using company data or databases (e.g. FAOSTAT or CROPWAT) for their inputs and whether the assessment is company-wide or for a specific product. If the necessary data are readily available, one qualified person can complete a product water footprint in a matter of weeks. It may take roughly five months for a product assessment and over a year for a company-wide assessment if a company must collect its production data. This process becomes progressively shorter as the amount of pre-existing database input used increases. It can take only one-to-two weeks when databases comprise a large portion of input data (Zarate, 2010) (Grant, 2010).

A full product-level WF assessment could cost roughly around 40,000-50,000USD. A company-wide assessment may cost anywhere from 50,000-200,000USD. The WFN Secretariat provides technical support at a rate of roughly 20,000USD for a product assessment and perhaps twice that for a company-wide assessment. Corporate personnel typically spend five person days per month to collect and analyze data, typically at a cost of 1,000USD/person day. The amount of time required of operations managers varies depending on the availability of data (Zarate, 2010) (Grant, 2010).

Life Cycle Assessment

LCAs vary in time and cost depending on whether the assessment uses more database data (i.e., a screening LCA) or more actual production data (i.e., full LCA), as well as whether the study looks at a wide range of indicators (e.g., GHG emissions, human health, ecosystem health, energy use) in addition to water use, or whether it is water-specific. A screening LCA typically takes roughly ten person days spread across one month to fully complete, while a full LCA takes 35 person days over 3-4 months. A LCA study considering only a company's water use and its impacts across its product portfolio takes roughly 260 person days over the span of a year consisting of *ad hoc* support from 5-8 employees (Milà i Canals, 2010).

Like WFN water footprints, companies usually conduct LCAs with assistance from an external organization with expertise in the field. Unlike water footprints, there is an extensive community of practitioners that provide such assistance. These external organizations typically charge 10,000-30,000USD for screening LCAs and 50,000-100,000USD for full LCAs when looking at a comprehensive set of indicators. These costs are typically cut in half (i.e., 5,000-15,000USD for a screening LCA and 25,000-50,000USD) when only considering water use and its associated impacts (Humbert, 2010).

Online Tools

As a free online offering, the WBCSD Global Water Tool is much less expensive than either WFs or LCAs to implement, and requires less time as well. However, like those methods, the amount of time and money required to use the WBCSD Tool depends on the size of the company, coupled with what it is attempting to accomplish. As mentioned, the WBCSD Tool can be used for a number of applications, although for the Tool's most common application—mapping a companies' and its supplier's facilities against water stress maps (i.e., hotspotting)—a company typically needs between a half-day-to-two-full-person days to assess its direct operations and more days in cases where companies have extensive supply chains. Conducting this exercise requires no special expertise; thus the only costs are those needed to cover the employee's time (Boffi, 2010).

Like the WBCSD Tool, both of the GEMI offerings are much less expensive and time-intensive than undertaking water footprints and LCAs. That said, quantifying the time and money needed for these GEMI tools is more difficult due to their focus on building corporate understanding of water issues rather than providing specific quantified answers. As such, reading the relevant guidance in these tools could take less than a day. Completing the Planner's risk assessment questionnaire is more demanding, but could still be completed in 1-2 person days if the company already has the necessary data relating to their operations and nearby watersheds (Van De Wijs, 2010).

Table 1: Summary of Scope and Structure for Major Corporate Water Accounting Methods and Tools

Criteria	Water Footprint	Life Cycle Assessment	WBCSD Global Water Tool	GEMI Water Sustainability Tool/ Planner
Definition	WFN's water footprint measures the total volume of freshwater used to produce the goods and services consumed by any well-defined group of consumers, including a family, municipality, province, state, nation, or business/organization.	A Life Cycle Assessment (LCA) is the quantification of the environmental impacts of a given product or service caused or necessitated by its existence. LCA identifies the environmental impacts incurred at different stages in the value chain.	WBCSD's online tool couples corporate water use, discharge, and facility information with watershed and country-level data. This allows companies to assess and communicate their water risks relative to water availability and access in their operations and supply chains.	GEMI's online tools help organizations build a water strategy. They assess a company's and its facilities' relationships to water, identify risks, and describe the business case for action that addresses companies' specific needs and circumstances.
Scope / Boundaries	• Water-specific – comprehensive measurement of corporate water use/ discharge only • Emphasizes "evaporated water" (i.e. consumptive uses)	• Assesses many environmental resources uses and emissions, including but not limited to water • Comprehensive measurement of water use and assessment of impacts • Measures consumptive and non-consumptive uses	• Water-specific • Rough measurement of water use and efficiency • Determines relative water-related business risks • Provides information on countries and watersheds	• Water-specific • Rough measurement of water use and assessment of key water impacts • Assess water-related business risks
Structure and Output	• Divided into blue, green, and gray footprints • Corporate footprints divided into operational and supply-chain footprints • Results provided in actual volumes	• Inventory results • Impact divided into several different types of quantified impact categories • Impacts by life cycle phase • Results can be expressed in weighted impacts across different impact categories	Provides many disparate components, including key water GRI Indicators, inventories, risk and performance metrics, and geographic mapping	• Tool divided into 5 modules: water uses, prioritized risks, risk mitigation, goals, water strategy • Planner divided into 3 modules: water use, risk assessment, case examples
Origins and Level of Maturity	• Fairly well-established with water resource management community • Relatively new to private sector • Corporate water accounting calculations and impact assessment methods and related support tools still nascent and under development	• Very well-established general method for environmental assessments of products, companies, and regional systems (e.g. water supply or wastewater management systems) • Water has only recently been considered as an area of focus • Methods for measuring water use and assessing related impacts are nascent and still evolving	• Introduced in 2007 and has since become commonly used in private sector • Version 2.0—featuring updated data and new types of date—released in 2009 • Currently in scoping phase to include energy component.	• The Tool was released in 2002; the Planner was released in 2007. • No publicly announced plans to further develop or expand

IV. Identifying Water-Related Business Risks

As one of the key drivers for water accounting, we will look closely at the types of water-related risks that businesses are exposed to, as well as the ways in which water accounting methods/tools are working to (and intended to) identify and mitigate them. Our headline conclusion is that all water accounting methods/tools reviewed for this study are generally good for risk identification purposes, particularly in terms of providing a "broad brush" understanding of relative water risk. However, each approach provides unique information, helping companies understand the nature of the risk in different ways.

THE INTERPLAY BETWEEN WATER-RELATED IMPACTS AND BUSINESS RISKS

Water-related business risks are closely related to water-related impacts. In most cases, companies with significant water impacts will be subject to corollary business risks. However, the inverse is not necessarily true: even companies with relatively insignificant water impacts may face major water-related risks. This is typically due to physical and/or socio-political factors that may change ***outside*** the company's fenceline. For instance, economic development or population growth in a region may increase pressure on water resources and thus jeopardize a company's continued access to water. New source water pollution may require (through regulation or otherwise) a company to install expensive on-site pretreatment technology so that the water is of suitable quality for production processes. In this respect, water-related impacts are just one (albeit a large) subset of issues that create water risk for a company. While it may be true that not all social and environmental impacts eventually manifest themselves as business risks, companies often find addressing major water impacts (both the company's impacts on others and vice versa) a prudent risk management strategy.

Impact assessments—discussed in detail in the following two sections—attempt to explore the implications of water use and discharge on "external" factors such as human health, community access to water, ecosystem health, etc. In contrast, assessments of business risks tend to focus more on exploring the implications of this water use and changing external circumstances on "internal" factors such as the company's legal access to water supplies and services, operational efficiencies, investor confidence, consumer perceptions, etc. Both types of assessments (risk and impact) require companies to consider how their own water use fits within the broader local water resource context. As such, the process for assessing impacts on watersheds, ecosystems, and communities is often linked to (or at times integrated with) the process for assessing business risks. For this reason, it is useful to consider water impacts and risks together; however, it is also important to note that the various water accounting methods/tools may have an emphasis on one or the other.

While some water accounting methods (e.g., LCA) are geared toward addressing the environmental and social (e.g., human health) ***impacts*** a company might have as a result of its water use and discharge, others focus instead on allowing companies to broadly understand their water risk, for example, by using place-based water indicators that contextualize the company's water use (e.g., WBCSD Global Water Tool). Others (e.g., water footprinting) aspire to shed light on both a company's business risks and impacts.

THE RANGE OF WATER RISKS

Companies' growing interest in water is driven by a number of factors, including pure operational efficiency, brand management, and corporate ethics/philanthropy. However, they are all ultimately driven by the desire to reduce related business risks whether that is to maintain social license to operate, build competitive advantage, encourage investment, or ensure long-term water supplies. The severity and type of these risks (as well as the appropriate mitigation strategies for them) depend on geographic location and type of industry sector and water use. That said, water-related business risks are often divided into three general and inherently inter-related categories:

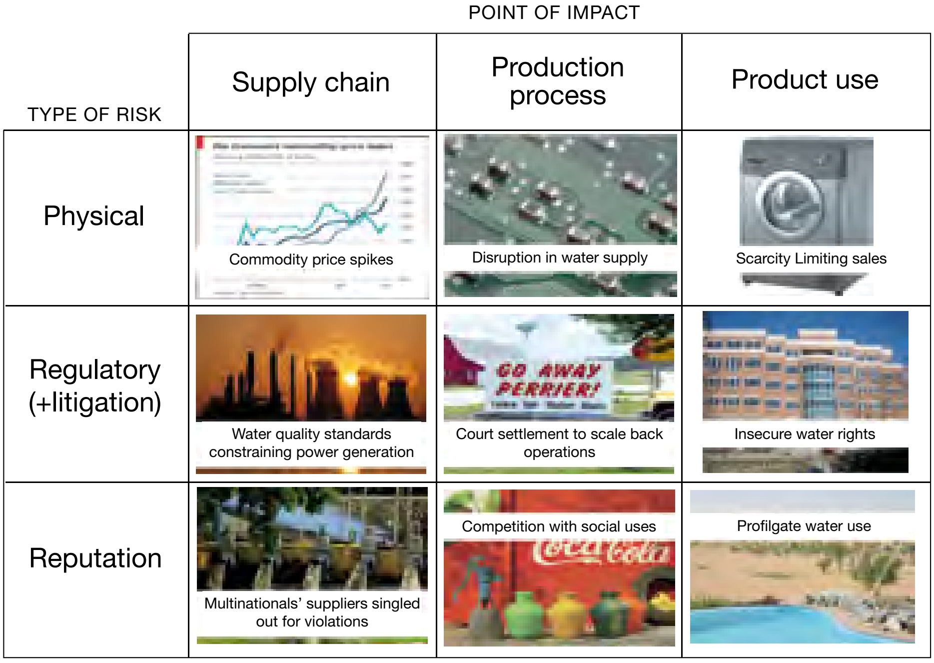
Physical: Physical risks pertain to the inability to access adequate water supplies or services to effectively manage a company's operations. This can be caused by drought or long-term water scarcity (i.e. insufficient and/or unreliable access to water); flooding (causing damage to infrastructure and/or disruptions in supply); or pollution, to the extent that such water is rendered unfit for operational use. This is most often a problem for companies with water-intensive operations in water-scarce regions. In many of those regions, climate change is exacerbating the problems of water scarcity.

Regulatory: Regulatory risks manifest themselves when policymakers and/or water managers change laws or regulations or management practices in ways that alter companies' access to water supplies/services, increase the costs of operation, or otherwise make corporate water use and management more challenging. Stricter regulatory requirements often result from water scarcity and/or ensuing conflict among various needs (e.g. ecological, urban, agricultural, industrial) or because of public perception of a company's water uses and discharges as wasteful, disproportionately harmful, or inequitable. Regulatory risk can also stem from poor management—and therefore an inconsistently applied regulatory framework—among a region's water managers.

Reputational: Reputational risks stem from diminished stakeholder perceptions (i.e., consumers, investors, local communities, etc.) due to inefficient or harmful production activities (or products) that have (or are perceived to have) negative water-related impacts on watersheds, ecosystems, and/or communities. Reputational concerns can lead to decreased brand value or consumer loyalty or changes in regulatory posture, and can ultimately threaten a company's legal and social license to operate.

All of the abovementioned risks lead to financial risks, which are created by increased costs or lost revenue due to the diminished status of the local watershed (i.e. scarcity or pollution) or the mismanagement of water resources. For instance, water scarcity or excessive pollution can lead to higher water prices, disruptions in production due to unreliable water supply, higher energy prices, higher insurance and credit costs, or damaged investor confidence, and therefore significantly affect the profitability of certain operations. New stakeholder expectations regarding corporate responsibility now expose companies to financial risks based on the perception of inefficient or inequitable corporate management of water resources.

Figure 2: Examples of Water-related Risk throughout the Value Chain



Source: Treating water – Sector report for engagement: Water exposure of food & beverage companies. Robeco Asset Management in collaboration with the World Resources Institute. April 2009

WATER FOOTPRINTING

Our research suggests that businesses consider water footprinting (WF) a useful framework for understanding and contextualizing their water use, and in turn, for identifying related water risk "hotspots" in their products, facilities, and/or supply chain. In this regard, WF can be considered quite effective for "big picture" strategic planning purposes and for helping companies prioritize actions and set long-term objectives and targets. The strengths and weaknesses of WF as a risk assessment tool are explored below.

Green-blue distinction

For companies that have undertaken WF, the distinction between blue and green WFs appears to be quite helpful. This is particularly (and perhaps mostly) the case for companies in agriculture-based industry sectors (such as food and beverage, textiles, etc.) due to their greater reliance on green water supplies. This may also prove true for companies with large land-use impacts such as those in the petroleum, mining, and forestry industry sectors, among others. With regard to agricultural production, blue water essentially is comprised of irrigated water (whether groundwater or surface water), while green water is comprised of the evapotranspiration of water naturally occurring in the soil from precipitation. Though evapotranspiration occurs in the absence of human intervention, it varies greatly depending on the type of land use (e.g., fields, orchards, pasture, forest) which humans frequently modify for agricultural purposes.

The green-blue distinction is helpful because these two types of water use create substantially different potential risks and have different impacts on the surrounding hydrologic region. Blue water use directly depletes aquifers and surface waters, thereby potentially contributing to water scarcity, destruction of ecosystems, and/or reduced access among human communities, among other things. There is often competition for blue water among users, sometimes leading to business risks when corporate water use hinders, or is perceived to hinder, other uses. In contrast, green water use does not deplete aquifers or surface waters, but rather uses water trapped in the soil. This typically does not create risks in and of itself, but can pose risks when it relates to changes in land use, for instance converting forest to agricultural land. Such land-use changes can impact biota and ecosystem functions.

The distinction between green and blue water is also perceived as useful in its capacity to assess long-term risks related to climate change. Climate change is predicted to have significant impacts on regional hydrologic cycles and the availability of water for human uses. Precipitation patterns will change on a regional basis, with rainfall often becoming less or more frequent and more concentrated depending on the location. This has many implications for blue water resources (e.g. infrastructure's ability to cope with longer droughts), but it particularly presents risks for operations in those regions heavily reliant on green water. Less frequent rainfall will ultimately mean less water stored in the soil. Because of this, those relying solely on green water use (namely agricultural growers in the Global South who do not have access to irrigation infrastructure) will simply not be able to sustain crop production through long droughts. This of course poses business risks for companies that rely on those growers as suppliers or that use large amounts of blue water in those same regions. For this reason, the green-blue water distinction in conjunction with climate change models can help companies better assess which of their water uses may be most susceptible to climate disruptions.

LIFE CYCLE ASSESSMENT

LCA is not typically characterized by companies and/or LCA practitioners as a water risk assessment tool, but rather a management decision support tool. Here, a distinction can be made between the different ways in which water accounting methods and tools define and address "risk." In some instances (i.e., WBCSD Global Water Tool), the focus is solely on business risks—how local water conditions might potentially damage a company's short-term or long-term viability, reputation, or profitability. However, a company's water use/discharge may pose risks in a number of ways: it can lead to an inefficient use of resources and therefore money and it can negatively impact the ecosystems and communities in which it or its suppliers operate, thereby creating potential regulatory and reputational risks.

A key characteristic of LCA is its emphasis on science-based environmental or human health impact assessment, which in turn can serve as an entry point for companies seeking to identify and understand water-related business risk. Such LCA assessments are typically carried out using complex fate-transport modeling and other relatively sophisticated modeling techniques. While distinct from direct business risks, these potential impacts to ecosystems and communities may ultimately have severe implications for business viability. In this sense, to the degree to which companies with significant water impacts will be subject to corollary business risks, LCA can help identify operational "hotspots" whereby product design and technical improvements can be seen as risk mitigation efforts.

WBCSD GLOBAL WATER TOOL

As with water footprinting, the WBCSD Global Water Tool appears effective at identifying water risk "hotspots." However, where WF delves into the nature of company water use to help identify and characterize risks, the WBCSD Tool emphasizes geographic location as the primary basis for a qualitative assessment of relative water risks. The Tool is typically used by companies seeking to identify "hotspots" across global operations by comparing sites' relative water stress. This allows companies to prioritize their mitigation activities on facilities in water-stressed watersheds which are presumably more likely to pose water-related risks. It does not provide an in-depth system for companies to account for water use or impacts.

The Tool provides companies with a series of data and maps that reflect country-level and watershed-level data and help identify risk. Metrics used to shed light on the nature and degree of risk based on the local water context include:

- Mean annual relative water stress index
- Access to improved water
- Access to improved sanitation
- Annual renewable water supply per person (1995 and projections for 2025)
- Ratio of industrial to total water use

The Tool allows companies to evaluate each of their facilities based on these "contextualizing" metrics. For instance, a company can use the Tool to determine what percent of its operations or suppliers are in regions considered to be under water stress or the percent of its employees who live in countries where populations have low/high levels of access to improved water and sanitation. By providing these indicators for each of a company's operations or key suppliers, the Tool helps to identify and characterize the risks that are prevalent on a site-specific basis.

GEMI WATER SUSTAINABILITY TOOLS

Both GEMI's Sustainability Water Planner and Tool can be used to assess water-related business risk. Like the WBCSD Tool, the GEMI Tools focus primarily on identifying and mitigating risks that occur because of issues external to the company operations (e.g., infrastructure, pricing, scarcity, etc.).

The Planner assesses the likelihood that these external factors might have negative effects on specific facilities. It is built around a web-based questionnaire that features seven components: General Information, Watershed, Supply Reliability, Efficiency, Supply Economics, Compliance, and Social Context. The Planner uses questionnaire input data to provide quantified "Average Risk Ranking" scores (0-5) for each of these components and provides links to variables, documents, and articles that may be relevant to the company based on their survey input. This helps companies identify specific issues that may pose the most significant risks in a particular area, and provides some preliminary information on how the company may mitigate those risks.

The Tool is focused on business-wide water-related risks. It is divided into three steps: 1) Water Use Risk Assessment; 2) Water Impact Risk Assessment; and 3) Prioritize Water-Related Risks. In the first step, companies answer a series of questions to determine the business importance of each water use; how sensitive the company is to changes in issues such as water pricing, availability, quality, or the loss of a specific water source; and the probability that these changes will occur. The second phase is a very similar analysis to step one but is focused on risks due to discharge and pollution.[4] Once these steps are complete, companies plot their water uses on a matrix that features business importance and chance of change on its axes in order to easily prioritize different actions.

[4] GEMI's references to "impacts" refers specifically to water discharge and pollution caused by the company, rather than the broader definition inclusive of water-use impacts used throughout the majority of this report.

V. Understanding and Responding to Impacts on Watersheds, Ecosystems, and Communities

The actual social and environmental impacts associated with corporate water use/discharge can differ drastically depending on the local water resource context (i.e., physical availability of water, in-stream flows, community access to water, etc.). A company using a certain amount of water per day in a large, water-abundant system will typically have less severe (if any) impacts on issues such as community access to water or ecosystem function than a company using the same amount of water in an arid region, or one where water is not equitably allocated to meet basic human and environmental needs. Impact assessments ultimately aim to understand and quantify the ways in which business activities may affect issues such as community access to water, human health, or the in-stream flows required for healthy ecosystems. A successful impact assessment provides companies with a factual basis for prioritizing management practices and tailoring mitigation/stewardship strategies to address the impacts deemed most important.

LIMITATIONS WITH WATER-RELATED IMPACT ASSESSMENTS

The process of understanding and quantifying a company's water-related impacts is quite complex, primarily due to the many criteria that can comprise the local water resource context and the difficulty in quantifying some of them, particularly the social aspects. Corporate impact assessments might be thought of as having two main components: 1) measuring and assessing the local water resource context, 2) overlaying and normalizing corporate water use/discharge within that local context. Both are wrought with challenges.

Measuring and assessing the local water context
Determining the local water resource context can be complicated and in many instances is reliant on subjective evaluations/or priority setting. For instance, determining "water scarcity" requires accounting for not only the physical abundance of water in a watershed, but also the quality of that water, the environmental flow requirements of the system, and the ability of people to access and/or afford adequate water services, among other things. The phrase "social and economic water scarcity" has been coined in order to express the idea that water systems can be considered "scarce" even in the presence of abundant physical supplies due to inadequate potable water and/or wastewater infrastructure.

Examples of criteria used to assess local water resource context include:

- Total amount of water physically available for use in that system;
- Total proportion of that physically available water currently being used;
- Allocation of water being used and its ability to meet demands (i.e., basic human needs, the environmental flows);
- Quality and safety of that water;
- Ability of local communities to afford adequate water services.

Because of the range of criteria a company could use to assess local water context, the resulting impact assessments are highly variable. As such, developing a comprehensive, yet efficient, system for measuring the local water resource context (i.e. physical, social, and economic scarcity) is critical to assessing impacts; however, a harmonized and objective approach to doing so does not currently exist.

Overlaying corporate water use with local water context
Once criteria for assessing local water context are established and measured, companies must compare these data with their corporate water use/discharge in order to gauge associated impacts. In the process of quantifying impacts, corporate water use and discharge data are adjusted or "weighted" to reflect local physical, social, or even economic water conditions. These scores allow companies to compare the impacts of various water uses in different watersheds and thus prioritize which business activities, facilities, and production stages are addressed. For instance, such characterization allows 20,000 gallons of water from a water-scarce region to be quantitatively shown as having greater relevance than 20,000 gallons of water from a water-rich region.

This process of quantifying impacts inherently requires a high degree of subjectivity in determining what constitutes a negative impact. For instance, a methodology must determine what constitutes sufficient in-stream flows, what constitutes basic human water needs, or at what point water is polluted to the extent that it is not available for use. Further, companies sometimes wish to compare different types of impact categories (i.e. impacts to in-stream flows, basic human needs, water quality, etc.), which adds an additional layer of complexity and subjective determination. While such comparison can be quite useful in prioritizing management responses, they are not scientifically valid: comparing impact categories requires a subjective assessment of what types of environmental and social activities provide the most value.

WATER FOOTPRINTING

As discussed, the WFN's corporate water footprint (WF) calculation itself does not attempt to account for the context of a watershed (e.g., water availability, allocation among users, etc.) or quantify or otherwise assess a company's water-related impacts. That said, the green-blue distinction within the WF itself does provide important information on the context in which a certain volume of water is used and that can help inform a cursory understanding of impacts. However, without broader watershed context data, a company is unable to assess key issues such as where and how its WF may infringe on other uses.

The WF calculation has been intentionally developed to provide a volumetric, "real" WF number that avoids any impact characterization as an inherent component. However, acknowledging the usefulness of understanding how water use volumes affect the condition of a watershed and its users, the WFN includes a "water footprint sustainability assessment (WFSA)" as part of a broader WF assessment. Once practice matures, WFSAs will overlay water use data with indexes that reflect the local water resource context in order to assess the WF in terms of its environmental, social, and economic sustainability. WFSAs will consider not only the location of water use, but also the timing. Few WFSAs have been conducted in practice, however many companies have expressed the need for such a method to be further developed.

The WFN is currently in the early stages of developing the *Water Footprint Decision Support System* (WFDSS), which will be the primary tool through which companies can conduct WFSAs. The WFDSS will be an interactive, open-source-software-based system designed to help decision makers compile a range of raw data to identify and solve water-related problems. The WFDSS will allow entities conducting WFs to assess: 1) the condition of the watershed in question (i.e., local water resource context); 2) the impacts of the entity's water use on that watershed; and 3) the appropriate response strategies to mitigate those impacts. WFN hopes such assessments will soon become a critical component of water footprint assessments worldwide.

Emerging company practice can already shed light on how companies are using WF to identify and manage water impacts. For example, some food and beverage companies have adopted the concept of "net green"[5] water—the difference between water evaporated from crops and the water that would have evaporated from naturally occurring vegetation. This allows companies to better understand their contribution to water stress in a particular area and how much water would be in the system if the company were not there. In particular, it highlights the opportunity costs associated with the company's green and blue WFs as compared to other possible uses in the watershed.

The blue and green dimensions of a company's WF also provide direction on how impacts can be managed. To mitigate blue water impacts and associated risks, companies might improve their water use efficiency or engage with affected parties to improve their access to water services. In contrast, the impacts and mitigation strategies for green water use are typically related to land use change rather than infringement upon other water uses. These land use changes—for instance the conversion of forests to arable lands—clearly affect ecosystem function (e.g., habitat and biodiversity), as well as communities' access to resources (e.g., timber). As such, companies may consider the distinction between green and blue water useful in helping them understand the types of impacts their production system might have on surrounding ecosystems and communities. However, at

[5] Though the Water Footprint Network acknowledges the importance of this concept for businesses, it believe the term "net green" is unhelpful in respect to WF's broader purposes. It advocates use of the term "changed runoff as a result of the green WF". However, the term "net green" has been adopted by many in the business community.

present, the WF community offers no guidance on how to interpret or value the different impacts of green and blue water use.

The handful of companies interviewed for this analysis indicated that while the individual WF components (especially the blue and green WF) were quite useful for informing management decisions, the total WF—the blue, green, and gray components aggregated into one number—is not as meaningful a number in terms of understanding a company's impact on water resources. This is based on the notion that there are substantially different types and severity of impacts associated with the blue and green WF and the fact that the gray WF, which is a theoretical rather than actual measured volume, should not be aggregated with the other two.

LIFE CYCLE ASSESSMENT

Several LCA studies have been published that use inventory data as the basis for evaluating the impact of water usage. These impact assessments are calculated by overlaying corporate water use and discharge data with characterization factors that reflect the local context (e.g., the respective water availability/scarcity and degree of human capacity to access water for each watershed).

There is currently a flowering of techniques for water-related impact assessment within the LCA community. The Swiss Ecological Scarcity Method 2006 developed by Frischknecht et al. was among the first to use regional conditions (i.e., relative water stress) as a characterization factor, thus allowing for water use to be assessed within a local context. The relative water stress levels—as determined by the percentage of the total renewable water resources consumed—were each given a weighting factor that could be used to characterize water use volumes, thereby serving as a rough proxy for relative impact.

Mila I Canals et al. (2009) identified two primary pathways through which freshwater use can impact available supply: 1) freshwater ecosystem impact and 2) freshwater depletion, in order to determine which water uses need quantification. They suggest surface and groundwater evaporative uses, land use changes, and fossil water as the critical water flows to be measured within the inventory phase.

Pfister et al. (2009) further developed methods for assessing the impacts caused by freshwater consumption. This study assessed impacts to: 1) human health (i.e., lack of water for drinking, hygiene, and irrigation); 2) ecosystem quality (i.e., damages to ecosystem functioning and biodiversity); and 3) resource availability (i.e., depleting water stocks) using a further-developed water stress index similar to that used by Frischknecht et al.

Most recent studies have been facilitated by the work of Pfister, who has produced global maps of water scarcity at the 0.5 minute scale (approximately the 1 km scale). The scale runs from 0 to 1 and includes both the effects of precipitation/evapotranspiration (the equivalent of WFN's "green" water footprint) and the effect of human withdrawals (approximating the "blue" water component).

Ridoutt and Pfister (2010) have introduced the concept of "liters $H^{2}0$-equivalent" which can be likened to the CO^{2}-equivalents seen in carbon footprinting. This enables a consumer to quantitatively compare the pressure exerted on freshwater systems through consumption of a product depending on local water context.

On top of this analysis, different authors have added:

- Human health impacts due to drought/malnutrition, in units of DALYs per liter of water;
- Socio-economic impacts due to the local ability to pay for water quality improvement;
- Biodiversity loss at dams and due to groundwater extraction.

A summary of the different methods can be seen at Kounina et al. (2009). In addition, a handful of LCA studies have now been published that attempt to use the volumetric measurements provided by water footprinting (i.e., blue-green WF) as the basis for an impact assessment. In doing so, a number of LCA authors have suggested redefining/augmenting the WF from a purely volumetric measure to a weighted index that results from multiplying volumes by impact characterization factors (Pfister et al. 2009; Ridoutt et al. 2009). While such a result allows for regionalized assessments and company evaluation of issues that may inform product design, WFN argues that such weighted and aggregated single numbers are not useful from a WRM perspective, as they can obscure temporally and spatially explicit data and also because the functional unit-relative results no longer provide data in real volumes. WFN believes it is useful to keep the volumetric measurement and characterization steps separate so as to accommodate the different (i.e., non-corporate-focused) applications of the WF methodology.

One limit to the utility-of-impact assessment within LCA lies in the lack of harmonization regarding models with which to evaluate available data, though better consensus is expected as the science of LCA continues to advance.

WBCSD GLOBAL WATER TOOL

The WBCSD Tool in no way attempts to assess how corporate water use in a particular watershed or country may lead to social or environment impacts, thus it not considered an impact assessment tool. To the degree to which the Tool helps companies identify water-stressed regions, it can serve as a rough proxy pointing companies toward regions where they are likely having their most significant impacts.

GEMI WATER SUSTAINABILITY TOOL

Both GEMI Water Sustainability Tool and Planner provide a set of qualitative questions and information that is meant to help companies identify, characterize, and prioritize potential water-related impacts, particularly those caused by wastewater discharge/ pollution. They do not provide a methodology through which companies can quantify impacts, but rather a compilation of information that can help them better understand what those impacts may be and how they might eliminate them. The Planner does so by directing companies to assess the degree to which changes to external supply and management could affect their access to this water and the impacts of their uses. The Tool focuses primarily on building corporate understanding of their sources of water (e.g. their relative water stress) and the ways the company impacts those sources.

Table 2: Summary of Accounting Approaches to Water Use-related Impacts

Criteria	Water Footprint	Life Cycle Assessment	WBCSD Global Water Tool	GEMI Water Sustainability Tool
Assesses water-related impacts?	As of yet, no. WFs do not attempt to assess impacts. Methods to quantify impacts though WF Sustainability Assessments are under development.	Yes. However, water-use-specific methods are nascent and need further development and harmonization.	No, but local context data highlighting water stressed areas can serve as a general proxy for relative impact.	Yes, but not comprehensively or quantitatively.
Types of impacts assessed	NA	Water use (proposed): • Ecosystem quality • Resource depletion • Human health	NA	Focuses on building understanding of the local water context and factors that could limit companies' access to water sources

VI. Accounting for Industrial Effluent and Water Quality

Though water quantity receives much of the focus in the context of corporate water management practices and accounting, water quality is equally important to businesses both in terms of risk and impacts. Untreated or insufficiently treated water can lead to increased incidence of disease, damaged ecosystems, and the inability of the company and other users to use such water. Thus, companies have just as great a stake in accounting for—and addressing —their risk and impacts associated with water quality as they do for water quantity issues.

As discussed, accounting for water use/quantity can be quite complex and requires meshing a number of different factors in order to be credible and meaningful. That said, accounting for industrial effluent and related impacts on water resources is arguably even more complex and problematic. This complexity is due to many factors, including the various different types of pollutants coming from industrial facilities and agriculture (e.g., phosphates, nitrates, mercury, lead, oils, sulfur, petrochemicals, undiluted corrosives, and hard metals, just to name a few); the interactions among pollutants; the variety of ways water quality can be compromised (i.e., contaminant loads, temperature, odor, turbidity), and the various approaches to accounting for the resulting impacts to ecosystems and communities.

Measurable water quality characteristics can be grouped into three broad categories:

- **Physical characteristics** (e.g., temperature, turbidity/light penetration, and flow velocity),
- **Chemical characteristics** (e.g., pH, salinity, dissolved oxygen, nitrate, phosphate, biological oxygen demand [BOD], toxics, chemical oxygen demand [COD]); and
- **Biological characteristics** (e.g. abundance of coliform bacteria, zooplankton, and other organisms that serve as an indicator of ecosystem health).

Companies aiming to account for their water pollution and its effects on water quality must determine a range of factors including the volume of wastewater they discharge, the types and loads of pollutants within that wastewater, the short- and long-term effects of those pollutants on receiving waterways, and the impacts of those changes on human health, human access to safe water, and ecosystem function.

DILUTION WATER AND THE GRAY WATER FOOTPRINT

Definition and Objectives

Water footprints deal with industrial effluents and water quality exclusively within the "gray water" component. The gray WF is calculated as the volume of water that is required to dilute pollutants to such an extent that the quality of the water remains above agreed water quality standards. Whether this water is discharged back to surface or groundwater, it is considered "used" because it is unavailable for human use due to the fact that it is functioning in-stream as a dilution medium. For this reason, the gray WF is a theoretical volume, rather than a real volume as compared to the blue and green WF.

The methodology for determining the gray WF is perhaps the least developed of the three WF components. In fact, many corporate WF studies to date do not include a gray water component. Those that do include gray water have done so in different ways. However, they all utilize some permutation of the same basic equation that uses one water quality regulatory standard to calculate how much water is needed to dilute pollution to acceptable levels. Because companies almost always release more than one pollutant (and typically dozens) to waterways, the methodology requires the company to select the pollutant with the highest required dilution volume. In theory, this dilution volume will then be sufficient for all other pollutants discharged. This method also requires the company to identify the most appropriate regulatory standard for the relevant pollutant and location of the discharge.

At the time of this writing, the authors were unaware of if and how the WF Decision Support System would address the gray WF on a watershed basis.

Limitations
While the concept of accounting for industrial effluents and water quality was unanimously considered important, companies familiar with the WF methodology have significant concerns (both conceptual and practical) with the gray water component its current form. Many felt that approaching water quality accounting through the assessment of dilution water volume has some fundamental disadvantages/limitations. The most notable of these limitations are the obscuring of contaminant load data and the base referencing of local water quality standards.

Specifically, focusing on the contaminant with the highest dilution water requirement is deemed a questionable approach, because in reality, industrial effluent typically contains a number of different types of contaminants, all of which have different implications, time constants and impacts for the surrounding environment. Further, a dilution approach cannot account for potential additive, synergistic, and long-term effects of the various types of persistent, bio-accumulating pollutants that may be discharged by a company.

Linking dilution water requirements to water quality standards is also problematic because these standards vary from watershed to watershed and in many localities do not exist (or are not available) at all. Not only does this mean that the required dilution volumes are dependent on political factors rather than scientific determinations, but this requirement adds additional complexity to the system, prompting questions such as:

- Which standard does a company use (e.g., national regulations, recommendations from intergovernmental organizations)?
- What do companies do in the absence of national standards or if national standards do not mitigate pollution to a level that protects communities and ecosystems?
- Does such an approach lead to an accounting bias in favor of countries with less stringent water quality standards, and/or incentivize companies to favor/give preference to operations in such countries?

Lastly, the dilution approach is deemed a circuitous route to addressing industrial effluents. Rather than directly accounting for the initial corporate water use/discharge, the gray WF focuses on a theoretical corporate response, which may or may not occur. In doing so, dilution—rather than prevention—is implicitly promoted as the desired solution to industrial effluent. Many consider pollution prevention to be highly preferable to dilution due to the fact that many pollutants persist and bioaccumulate and impacts occur even when dilution volume is considered adequate to meet regulatory standards. Furthermore, this approach obscures and de-emphasizes important information about the type and amount of pollutants released to waterways, as well as potential ways to reduce these pollutants. Finally, the WF gray water accounting method does not address water pollution transported to waterways through air pollution, the predominant source of water pollution in many industrialized nations.

In the gray water approach, the WF's typical inclination toward real numbers that require little human subjective assessment is replaced by a methodology that requires highly variable and subjective standards. Because of these fundamental differences between the gray water component (a theoretical volume characterized based on water quality standards) and the green and blue water footprints (real volumetric measures), the handful of companies surveyed for this analysis indicated that aggregating the gray component along with the green and blue components is misleading and of little use.

DIRECT ASSESSMENT OF CONTAMINANT LOAD INTO WATERWAYS / LCA APPROACH TO WATER QUALITY

In the context of water pollution, LCA methods are already well-developed and widely accepted. They are aimed at a number of different environmental impact categories independent of whether the emissions occur to water or to some other medium. The most common impacts associated with water quality in LCA are:

- Eutrophication (overgrowth of algae due to excess nutrient addition)
- Acidification due to emissions of acidifying substances (mostly into the air)
- Ecotoxicity (potential for biological, chemical or physical stressors to affect ecosystems)
- Human toxicity

These impact categories are measured in terms of equivalents of eutrophication potential (phosphorus or nitrogen units); acidification potential (hydrogen ion or sulfur dioxide units); and ecotoxicity potential (cubic meter-years). Because these units are not the same, these impacts cannot be added up without a value judgment for normalization and weighting of the impacts, for example as is done for eco-indicator points or end-point indicators.

There is research going back to the 1990s that evaluates ecotoxicity potential with impact units of cubic meter years, adding up the impacts of the many different toxic substances. These analyses are based on a so-called “unit earth” or fugacity standardized fate and transport model for toxic pollutants (regardless of their medium). Information on the ecotoxicity of the individual pollutants and their persistence in different environmental compartments must be known or estimated. This kind of model is the most closely related to the Water Footprint Network’s gray water.

It is possible to report loads of pollutants to waterways through the simple addition of the mass of emissions to water, but this is not practiced within the LCA field because there is no way to describe the environmental mechanism to support the calculation. In effect, such a calculation would be saying that there is no science behind the analysis.

The use of these life cycle impact models and reporting on the product basis supports all the basic purposes of LCA (decisions for engineering, policy, and purchase and sales) as described above. It helps businesses understand the risks of different environmental effects for processes within the control of the business and also for those outside the direct control of a business. Of particular interest are the impacts of a product downstream (the use and recycle/disposal phases). Although manufacturers do not control the actions of their customers, in the case where a manufacturer designs a product with the use and disposal phases in mind, these phases can be shown to have fewer polluting impacts.

Limitations
LCA is limited to the impacts for which there is good enough science to perform impact assessment. LCA is a relative method, normalized to the functional unit defined in the study. It is not typically applied to a whole ecosystem or whole watershed analysis, and therefore is seldom used by water resource managers. On the other hand, the broad application to the entire life cycle of the product allows managers to understand where it is possible to manage or influence the product’s overall outcome.

WBCSD GLOBAL WATER TOOL

The WBCSD Global Water Tool does not measure or otherwise assess water quality or industrial effluent.

GEMI WATER SUSTAINABILITY TOOL

The GEMI Water Sustainability Tool encourages companies to analyze their pollution to water bodies (which they perhaps confusingly refer to as “water impacts”). It does not provide any method or guidance for the measurement of industrial effluents or quantification of impacts to water quality. It looks at both pollution caused by a company’s direct discharges to the environment as well as more indirect avenues of pollution such as air deposition and the leaching of chemicals. It provides a series of questions (categorized by value chain stage) that help companies better understand their effects on the pollution of water bodies.

Table 3: Summary of Accounting Approaches for Water Quality and Industrial Effluent-Related Impacts

Criteria	Water Footprint	Life Cycle Assessment	WBCSD Global Water Tool	GEMI Water Sustainability Tool
Assesses water quality?	Yes	Yes	No	Yes, but not comprehensively or quantitatively.
Basic approach	Dilution volume	Direct measurement of mass or volume of contaminants	NA	Qualitative review
Types of criteria assessed	Most harmful contaminant (often nitrogen) based on discharge quantities and local regulatory standard	Impact categories: • Eutrophication • Acidification • Ecotoxicity • Climate change • Human health	NA	Queries company on types of pollution in various value chain stages
Potential limitations	Only accounts for primary pollutant (i.e., disregards additive and synergistic effects). Uses local regulatory standards rather than direct measurement and scientific assessment	Does not typically quantify impact to specific local receiving bodies; results are relative to functional unit which seldom is scoped at the watershed level.	NA	No measurement or quantification

VII. Conveying Water Information to Stakeholders

Historically, companies have typically used internal proprietary software and/or undisclosed metrics when carrying out water accounting for internal management purposes. In recent years, companies have been increasingly expected to disclose the results of their water accounting to key stakeholders and the general public. These expectations have led to the development of harmonized measures, metrics, and indicators on corporate water use by third party interests, most notably the Global Reporting Initiative (GRI), and, most recently, the Carbon Disclosure Project (CDP), in order to support consistent and meaningful corporate disclosure of water information. Emerging corporate water accounting methods, such as water footprinting and LCA, are also increasingly being used to inform water-related disclosure by companies. This section will discuss how water accounting methods and tools can be used to support corporate disclosure efforts and provide an overview of other third-party initiatives that have developed reporting metrics and protocols.

A significant portion of corporate water-related reporting is qualitative, with companies providing descriptions of various water stewardship initiatives, principles, policies, programs, and goals. However, companies are perhaps more intently evaluated based on their reporting of quantitative information. Theoretically, such quantitative reporting could be about any of the findings from corporate water accounting efforts, including the local water context of their operations and the quantified impacts to watersheds, communities, and ecosystems. In practice, however, companies almost always report a much more limited and context-neutral set of information, such as their total water use, total wastewater discharge, water use efficiency, or total amount of recycled water. Such metrics usually serve as the basis for most companies' social responsibility reporting regarding water, though the meaningfulness and legitimacy of such generic and aggregated data are widely disputed (JPMorgan 2008, Pacific Institute 2008).

THIRD-PARTY WATER DISCLOSURE METRICS AND PROTOCOLS

The use of harmonized metrics or indicators on corporate water use developed by third-party interests is often seen as one factor in credible corporate sustainability reporting. The most widely used and accepted metrics for sustainability reporting are developed by the Global Reporting Initiative (GRI). GRI's most recent reporting framework, known as the G3 Guidelines, contains indicators for the economic, environmental, and social performance of companies, including five core indicators specifically focusing on water-related issues:

1. Total water withdrawal by source
2. Water sources significantly affected by withdrawal of water
3. Percentage and total volume of water recycled and reused
4. Total water discharge by quality and destination
5. Identity, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the organization's discharge of water and runoff

While certainly useful, these indicators are limited in the nature and scope of information they provide. First, as discussed throughout this paper, strict volume measurements of water use/discharge alone do not capture the risks and impacts that vary depending on the relative local water conditions. Furthermore, aggregated company total water use data without regionally specific volumes obscures important relative water scarcity contextual information.

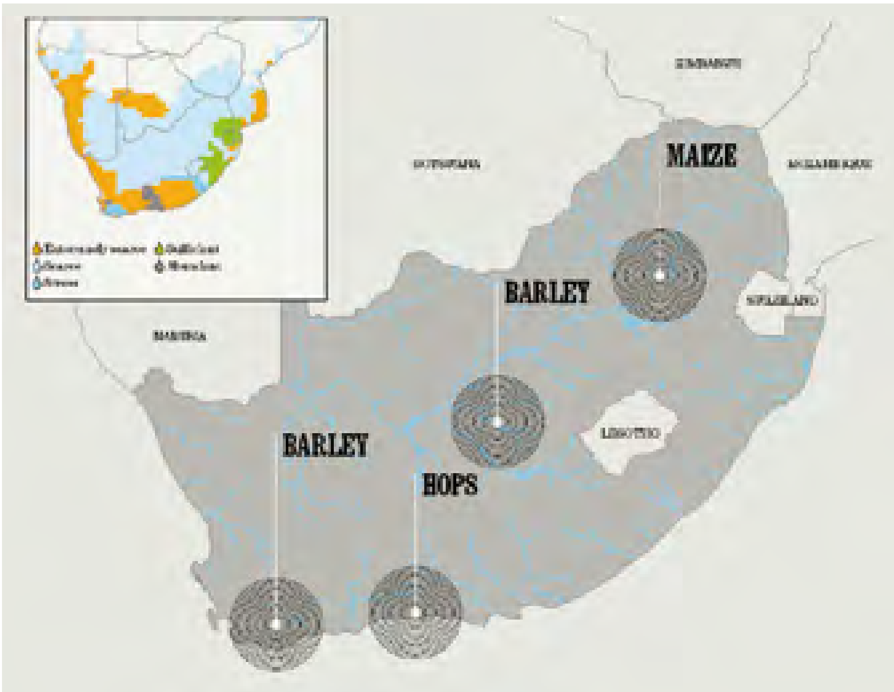
The Carbon Disclosure Project (CDP)—an organization that collects information from companies worldwide regarding their greenhouse gas emissions and climate change strategies—is currently developing a similar framework through which to collect companies' water-related information and policies. The first iteration of the annual CDP Water Disclosure Information Request will be sent to companies to disclose against in April 2010 (with results reported in Q4 2010). It demonstrates an increased sophistication in what is asked of companies in respect to their understanding of their interaction with water resources. For this analysis, perhaps the most relevant of CDP Water Disclosure's requests are: 1) an in-depth examination of water-related business risks and 2) an assessment of the local context in which companies operate (e.g. the proportion of facilities located in water-stressed regions). The CDP Water Disclosure Information Request asks that companies disclose this data for their own facilities, as well as their suppliers. CDP Water Disclosure's new framework underlines the fact that not only do these types of analysis help drive down water-related impacts and risks, but they are also becoming expected of companies by investors, consumers, and other key stakeholders.

WATER FOOTPRINTING

WFs are beginning to be used as a reporting/communication tool, though the appropriateness of this use is questioned by some. These concerns are based on the notion that generic and aggregated claims (such as 2,500 liters of water to produce one cotton shirt or 960 liters of water to produce a liter of wine) are inherently misleading and/or meaningless because they obscure essential information regarding the local context and nature of the water use, and therefore do not reflect impacts or risks. For this reason, total water footprint calculations can be very easily misused and misconstrued. For instance, Raisio, a Finnish food company, has produced a water "ecolabel" for its products that essentially uses a product's total water consumption as the basis for its scores. Such scores do not speak to the source of that water (i.e. blue or green) or the conditions of the watershed from which it was taken and thus have little value in terms of assessing the sustainability of a product's water use. That said, more detailed reporting of WF studies has served to help companies be accountable to (and receive feedback from) key stakeholders, as well as help build a good reputation relating to water transparency and responsible water practices. More generally, proponents have also identified WF as an effective awareness-raising tool for business, consumers, and policy makers on water issues worldwide.

WF studies typically use maps and other visualizations to express data and results. Though such visualizations are not provided for or required by the WF methodology, they have become common practice for WF studies. These maps can illustrate internal data such as facility locations and water use, as well as external data that contextualize the WF data, such as different water users within a system and the relative water scarcity of different regions. This not only allows companies to visually locate (i.e., “hotspot”) potential impacts and risks (e.g., linking facility sites with water scarce regions or where their water uses may potentially infringe upon other uses), but is also emerging as a particularly powerful communication tool. Corporate sustainability managers have found these maps very effective in communicating with non-technical audiences, both internal (e.g., upper management) and external (e.g., investors, consumers, local communities).

Figure 3: An example of water footprinting study visualization



Source: Water Footprinting: Identifying and Addressing Water Risks in the Value Chain. SABMiller and WWF-UK. August 2009.

Water policy and management interface

Water footprinting has also proven to be useful for companies who look to engage with stakeholders (particularly water policy makers and managers) to manage impacts and advance sustainable water management beyond their fenceline. Companies can use WF to highlight where major water uses are in the value chain to prioritize where they might focus their external engagement. For instance, if a company determines that the majority of their water use occurs in agricultural production, they could work with local growers (and suppliers) to implement efficiency improvements. Companies could also work with academia to further develop technologies that support these efficiency improvements. Similarly, companies could work with water managers to conserve water (e.g., through funding the repair of pipes), which is often cheaper and saves more water than internal efficiency improvements. If companies determine that their water use is hindering environmental flows or community access to water, they could partner with local NGOs to find effective solutions. Water footprinting is particularly well suited to help inform corporate engagement with water policy and management because it was originally designed as method for assessing WRM (and therefore many managers and policymakers are familiar with it). Its effectiveness as a communication tool for non-technical audiences also makes it particularly useful to this end.

LIFE CYCLE ASSESSMENT

For some time, LCA outputs have been used to inform environmental purchase and sales decisions. This occurs either as a support for environmental claims or as the supporting information for LCA-based (i.e., Type I and Type III) ecolabels. In this context, LCA is useful to program operators of ecolabel programs, whether they are governmental or private sector programs. Type I labels are provided for products whose life cycle performance exceeds set standards. In contrast, Type III environmental product declarations (EPDs) merely disclose performance in a pre-set fashion by product category rules and make no claim of environmental superiority. EPD programs require LCA studies to be performed for all products seeking the label. EPDs are becoming a requirement under law in some countries, such as in Northern Europe. Almost all EPDs are aimed at the business or institutional customer. If and when the labels become available in a consumer setting, they will have to be accompanied by a substantial educational effort. Studies on nutrition labels, for example, show that even decades on, the consumer is confused about the meaning of the information, and environmental information is even more obscure to the average consumer.

The general framework for and validation of LCA studies is governed by the relevant ISO[6] standards:

- ISO 14040 and 14044 (the life cycle standards)
- ISO 14025 and 21930 (the EPD standards)

In general, these standards require higher levels of verification as the use of the data becomes more public and more widespread. The required/recommended validations are:

- For internal use only, verification by a co-worker who was not involved in the original study.
- For external use (what is called a third-party report), verification by a panel of at least three, including LCA experts and interested parties.
- For EPDs, there are two levels of verification: the first for development of the product category rules, which requires a panel of experts and interested parties, and the second for EPD product-specific LCA study, which requires only an independent individual. The standards call out the requirements for LCA experts, including that they be independent (with no conflicts of interest) and be technically competent in LCA matters and in the specific elements of the EPD program and the relevant standards. The review team must also have expertise in the products and processes under consideration.

WBCSD GLOBAL WATER TOOL

Though limited in the scope of data it addresses, the WBCSD Global Water Tool can serve as an effective communications tool due to the fact that it is easily understood by non-technical audiences. Companies are increasingly starting to include brief summaries of the proportion of their operations in water-stressed and water-abundant regions in their CSR reports and often use the WBCSD Global Water Tool as the basis for this assessment. Furthermore, the Tool converts the water use and discharge input data into GRI G3 indicators for total water withdrawals (GRI EN8); total recycled water use (GRI EN10); and total water discharge (GRI EN21). This allows companies to easily quantify and report their water use in a manner that is harmonized and comparable across many businesses and industry sectors.

GEMI WATER SUSTAINABILITY TOOLS

The GEMI tools are geared toward internal assessments at the facility- and company-wide level and are not designed or generally used as communication tools.

[6] ISO is also currently developing a standard specifically for water accounting, discussed further in Appendix B.

VIII: Data Limitations

Water accounting methodologies use data as inputs that serve as the basis of their analyses. Input data can describe corporate water use and discharge or the local water resource context (e.g., local water availability, access to water, etc.). Which types of data are used, and at what resolution, are key components in determining for what applications each methodology is most useful. Further, the data generated by the databases imbedded with these various corporate water accounting methodologies are of key importance to their overall effectiveness. However, data can be, and often are, quite lacking in many different regards. Indeed, at present, insufficient data is one of the biggest limitations to meaningful water accounting, and therefore companies' understanding of their water-related risks and impacts. This section will explore three different types of data-limitations issues in water accounting, as well as the implications of these limitations on a company's ability to derive meaningful results. These three types of limitations are:

- Inadequate databases
- Lack of access to data
- Insufficient granularity of data

Inadequate databases
Water footprinting and LCA often use pre-existing databases in order to inform or supplement their analyses. Both methods depend on databases of average water uses when direct data are unavailable. For instance, companies often use databases that include the average amount of water needed to grow a certain type of crop (and often specified by irrigation type), and to a lesser extent the average amount used for a particular manufacturing process, if they do not have the money or time to measure such water use directly. The most common databases for evapotranspiration and crop growth are the EPIC model and the FAO's CROPWAT model. LCA also uses databases as a way to understand the local water resource context. Perhaps most commonly, LCA uses global water stress indexes that include the approximate amount of water available in many different locations around the world.

However, as of now, these databases are in almost all cases insufficient or could use improvement. Databases used to estimate averages are typically simply not available. When they are available, they are often not specific enough (e.g., average crop water use but not specified by irrigation type or climate type). Furthermore, the use of such databases would not reveal if a company or facility was particularly efficient or wasteful in any particular area (compared to averages) and therefore would not be useful in identifying areas for improvement that could be addressed relatively easily and result in high water savings. Databases used to understand the local water resource context are more commonly available, yet are often available only at the national level and often use methodologies that can be misleading. National-level data on water stress is often not useful because many nations have watersheds with drastically different water availability (e.g., the American Southwest and Pacific Northwest regions of the United States). The most common indicator for water stress is simply the volume of physically available water per capita. However, this measure obscures the potential for limited access to water due to economic problems, a governance deficit, or inadequate infrastructure.

Lack of access to data and databases
Companies often do not have access to the data necessary to conduct meaningful analyses of their water use and discharge. This can be due to inadequate internal and supplier measurement practices, insufficient data collection of external conditions by the appropriate parties, or databases of external conditions that are not publicly available due to political reasons.

Companies, particularly SMEs, do not have the infrastructure, employees, or systems in place to regularly and comprehensively collect their water use and discharge data. This can be due to financial limitations, lack of technical expertise, or the fact that until recently accounting for water use has been relatively low on companies' list of strategic concerns and therefore companies have not implemented effective data collection systems. In order to understand their water-related risks, companies must invest in their capacity to conduct assessments of their water use and discharge, as well as the status of the watersheds in which they and their suppliers operate. In many cases, companies buy their goods as commodities, and are not aware of the upstream impacts of their purchasing choices. In the same way, the global market means that goods are shipped worldwide through the efforts of purchase and sales agents who know (or disclose) little about either the upstream or downstream water situations relevant to the goods they handle.

Even when databases of external conditions do exist, governments or private interests that manage them may be unwilling to share them with companies or the public. For governments, this may be due to a fear that data revealing that the country is under high water stress might deter companies (or their investors) from their jurisdiction. For private sector actors, this may be driven by profit motives. In these situations, companies often have to collect their own data regarding the local water context to the best of their ability or try to encourage governments and private practitioners to become more transparent with their water data.

Insufficient precision of data

Another way in which the data underpinning water accounting methods can be limiting is in their granularity/resolution. Using data that shows the watershed (and perhaps the location within the watershed) from which water was taken or wastewater was discharged can be incredibly valuable in helping determine how that use might impact others in the watershed. For example, a company that knows where its facilities are using water in a system compared to where other users are withdrawing that water can let them know to what extent they are affecting others' access to water. Similarly, adequate temporal resolution of water use data can allow companies to assess water-related impacts and risks during different seasons and at different points in the hydrologic cycle. However, as of now, water use data is typically presented as an annual total.

Finally, in addition to the problems posed by insufficient data, it is also important to note the limitations of quantitative assessments of water use, discharge, and impacts in general. Though certainly effective at hotspotting certain water-related risks and identifying physical water stress, quantitative analysis is not able to show less concrete issues, such as mismanagement of water services, governance deficits, the attitude of nearby communities' toward the company, and a number of other societal and political factors that cannot be measured. These factors can create risks for companies just as easily as wasteful water use or physical water scarcity. For instance, a company can use water quite efficiently and operate in a relatively water-rich area, but if the government that manages water resources in that watershed does not have the capacity or desire to manage water sustainably and equitably, the company will be exposed to risk. For this reason, in addition to quantitative corporate water accounting, companies should invest time and money in better understanding the systems that manage water for their facilities and the communities and various other water users that are served by those systems.

IX. Water Accounting and Other Sustainability Accounting Methods

Water use and pollution is by no means the only aspect of sustainability that poses risks for companies and must be measured and assessed. Companies must also understand the contribution of their greenhouse gas (GHG) emissions to climate change; the impacts of their energy use on business costs, the environment, and human health; and a number of other resource uses and emissions. As such, several accounting methodologies akin to those analyzed in this report have been developed for other sustainability issues, such as GHG emissions or natural resource depletion.

The interactions and linkages between many of these sustainability issues are becoming more and more clear, particularly among water, carbon, and energy. Climate change--heightened by corporate GHG emissions--drastically changes the hydrologic cycle, leading to more frequent and severe drought and flood events and contributing to water scarcity. Transporting or pumping water for irrigation or desalinating it for other uses is often incredibly energy intensive. Likewise, creating energy often (as in the case with hydroelectric dams) severely damages aquatic systems, displaces communities, and creates human health concerns. These inextricable links between these three sustainability issues have become known as the "Water-Energy-Carbon Nexus". Companies are now increasingly concerned with understanding the ways in which these resource uses and emissions interact with and affect one another and how these linkages might inform a company' assessment of impacts and risks.

This section will provide a synopsis of accounting methods for other sustainability issues as a basis from which to explore how public perception and understanding of those methods might confuse water accounting, as well as how different sustainability accounting methods interact with one another and are compatible. It will focus on carbon accounting and ecological footprinting, as they are perhaps the most established and widely recognized of these methods.

CARBON ACCOUNTING

Carbon accounting (commonly referred to as "carbon footprinting") measures the total amount of GHG emissions caused directly and indirectly by an individual, organization, event, or product. This measurement is divided by the various types of GHG emissions (e.g., carbon dioxide, methane, ozone, nitrous oxide) and can be assessed for any type of carbon emitting entity (e.g., individual, city, nation, product, company, etc.). A carbon footprint of a company or product ideally includes emissions from all stages in the value chain. A specific methodology for corporate carbon footprinting has been developed in the WRI-WBCSD GHG Protocol (and subsequently adopted as the basis for an ISO standard). Several methodologies exist for product carbon footprinting.

Three different scopes have been described for carbon footprinting. Scope 1 is the direct GHG emissions of an organization. Scope 2 is Scope 1 plus upstream GHG emissions associated with the production of energy used by the organization. Scope 3 is Scope 2 plus the life cycle GHG emissions of all the products purchased by an organization. The Scope 3 carbon footprints are simply the climate change results of all LCAs.

Carbon accounting is fundamentally an assessment of impacts, rather than a strict measurement. After measuring the amount of emissions for each type in real masses, each mass is multiplied by a characterization factor that "weights" that mass based on the type of gas emitted, using factors developed by the Intergovernmental Panel on Climate Change (IPCC). The characterization factors are based on the relative global warming potential—their contribution to climate change per unit—of each greenhouse gas. Once this weighting occurs, all the masses are expressed in terms of carbon dioxide equivalents which allows for comparison and aggregation of different types of emissions across different products, facilities, and companies. Companies use this to assess the impacts of different types of emissions and evaluate the extent to which their entire business, their products, or their facilities contribute to climate change in order to prioritize areas for improvement and to assess business risks.

Carbon footprinting has led to the concept of carbon offsets: the idea that one can pay others to reduce their pollution for less money than required to reduce their own pollution. Offset schemes have been criticized on a number of fronts. Of particular concern are issues related to "additionality" (i.e., would the carbon reduction project have occurred without the offset?) and whether they lead to actual improvements in the atmosphere. There are also questions about the actual methods of accounting for carbon emissions, especially as they relate to land use changes and biofuels. Despite these concerns, the potential to offset water use is even more questionable than the potential to offset carbon emissions due to the extent to which impacts differ depending on the location and timing of use.

Due to the presence of characterization factors, carbon footprinting is often an integral part of an LCA. However, the carbon footprinting approach is fundamentally different from water footprinting (as defined by the WFN) which only provides volumetric measures of different types of water from different locations. The WFN's water footprinting includes no characterization factors that allow different types and sources of water to be compared based on their impacts. That said, a number of LCA practitioners, applying the characterization methods of Frischknecht or Pfister, are including water resource results (which they are dubbing "water footprints") as part of broader LCAs showing the trade-offs among different impacts (e.g., water use and land-use related impacts). Due to the present confusion around terminology, any conclusions made about "water footprinting" based on one's understanding of carbon footprinting should be scrutinized carefully.

ECOLOGICAL FOOTPRINTING

The Ecological Footprint (EF) is a resource accounting tool used widely by governments, businesses, educational institutions, and NGOs to measure the biological capacity of the planet that their activities or products require (Global Footprint Network 2009). Biological capacity is defined as the area of productive land and sea required to produce the resources consumed by humans and to neutralize the subsequent waste. An understanding of biological capacity can help these entities better manage their operations and communicate with stakeholders. An EF compares human demand on nature to the availability of nature. It therefore can be considered an impact assessment (though quite different in appearance than impacts assessments for water use), rather than a straight measurement like that seen in water footprinting. The methodology of the water footprint has been inspired by that of the EF, but was adapted by Prof. Hoekstra to water-specific circumstances. The current EF method also reflects the reality of data limitations for describing biocapacity demand of water.

An EF is categorized into a number of different individual footprints (i.e., Food, Mobility, Housing, and Goods and Services). The Footprints can also be divided into the various land types that are needed (i.e., forest, grazing area, fisheries, etc.). The common measurement unit of both Ecological Footprint and its counterpart, biocapacity, is global hectares. These hectares correspond to biologically productive hectares with world average productivity. Ecological Footprinting is most often used in educational or communication settings to help quantify ideas like "sustainable development." The tool is also increasingly being applied in policy settings.

Ecological footprinting does not include water footprinting or any other form of water accounting; current assessments only capture freshwater impacts indirectly. While the carbon footprint is a direct subcomponent of the EF, despite the similarities in terminology, EF and water footprinting are not directly linked methodologically. The main reason is that each unit of water use has a distinct demand on biocapacity depending on the local context. Such calculations have not been possible due to the aforementioned data limitations.

COMPATIBILITY OF SUSTAINABILITY ACCOUNTING METHODOLOGIES

Neither carbon accounting nor ecological footprinting assess water use or pollution. Similarly, water footprinting and other water accounting methods do not account for carbon or other sustainability issues such as energy use. However, as mentioned earlier, the links between these different sustainability issues in terms of impacts to watersheds, ecosystems, and communities, as well as in terms of business risks, are undeniable.

Insofar as companies and products are concerned, LCA is the most well-established and well-suited system through which to assess different sustainability issues and their common and different impacts. Done properly, carbon accounting is streamlined as part of an LCA such that GHG emissions and their contribution to climate change can be integrated into broader product assessments. Because of this, LCA is well-positioned to allow carbon-related impacts to be compared with other types of environmental impacts (including those related to water use and pollution) incurred in a product's life cycle.

X. Advancing Corporate Water Accounting Practices

While the methods and tools explored in this analysis are all effective for certain purposes, there remain a number of factors that hamper companies' ability to effectively measure, assess, and report their water use and impacts. These limitations are due to a range of issues including relatively nascent methods/tools, lack of capacity among company personnel, insufficient water management and governance infrastructure, lack of cooperation and harmonization among key actors, and inadequate communication and engagement with relevant stakeholders.

As mentioned in the Preface, this report is part of the broader UNEP Water Footprint, Neutrality, and Efficiency (WaFNE) Umbrella Project, which strives to enhance water efficiency and water quality management through the refinement and pilot testing of emerging water accounting methods and supporting management tools. Among other things, this WaFNE project aims to encourage convergence of practice and compatibility among these methods. One of the key components of this project is a country-level pilot testing of methods that will further explore the practical application and advancement of the methods/tools discussed in this report. These pilots will aim to test:

- Implementation of water use/discharge self-assessment tools at the company/factory level;
- Appropriate stewardship responses based on corporate water accounting outcomes;
- Use of indicators and management guidance to report the water accounting findings to stakeholders and the broader public.

One of the objectives of this analysis is to shed light on the areas of corporate water accounting that can be improved via this upcoming on-the-ground pilot testing. Based on our findings, below is a series of recommendations regarding how UNEP-led pilot testing might advance corporate water accounting and stewardship practices in general.

1. Assessment of local water resource context
Historically, corporate water accounting has focused on the amount of water used within a company's direct operations, focusing on ways to reduce use and drive down corollary costs and risks. However, this report, among others, highlights that companies are often exposed to risks associated with external factors such as water scarcity, pollution, or inadequate infrastructure or public water management, even if their internal operations are quite efficient and responsible. For this reason, corporate water accounting is increasingly looking to better measure and assess the external economic, social, and environmental contexts of the watersheds in which companies operate. While practice in this area is certainly improving, much still needs to be done in terms of consistent approaches to assessing external conditions (e.g., partnering with water managers and NGOs who collect such data); identifying effective metrics (e.g., determining appropriate measures of water stress); and harmonizing such approaches. This is particularly true for social criteria, such as access to water, affordability of water, and human health.

Pilot testing can help advance these local assessments by exploring different types of criteria that can be used to quantify environmental and social conditions; innovative practices for data collection; and effective ways of communicating with water managers, governments, communities, and local NGOs. Ideally, this will lead to a convergence of practice with respect to understanding, quantifying, and reporting physical, economic, and political water scarcity, and will contribute to an effective method of assessing how companies perpetuate or mitigate that scarcity over time.

2. Assessment of supply chain
While many companies recognize that much of their water use and impacts (and in many cases the majority) occurs in their supply chain, current corporate water accounting practice does not adequately emphasize suppliers' water use and discharge. This is largely due to the difficulty in obtaining reliable data from a vast network of suppliers worldwide, as well as the fact that many companies buy their supplies on global commodity markets that obscure the source and production history of those goods.

Pilot testing can help develop more robust and systematic ways to address suppliers' water issues, by improving efficient data collection systems in complex supply chains and promoting innovative ways to communicate and incentivize this responsible practice to suppliers. In particular, pilot testers can help suppliers implement management systems that help collect this data, educate suppliers on the rationale and process for improved water stewardship, and/or establish supplier guidelines that require this information.

3. Improved data collection
Our report found that one of the key limiting factors for nearly all accounting exercises is the lack of reliable data at a sufficient level of detail/granularity. While supplier data, discussed above, is a large component of this, companies are also lacking with respect to their own production data and external watershed data. Many companies rely on generic databases that report regional averages rather than their own production data. While this can be useful in quickly identifying material issues, it is not sufficient for a comprehensive assessment of a company's water use.

In addition to improving the ability of suppliers to collect and report such data, pilot testing can also build the capacity of their operations managers so that they understand corporate needs and implement appropriate practices. This could be achieved through management systems, corporate mandates, and training programs. Further, pilot testing can explore avenues through which companies work with governments, civil society groups, and local water managers to access watershed-level data regarding environmental flows, access to water, water quality, etc. that will support their impact and risk assessments.

4. Assessment of water quality

Previous corporate water accounting efforts have focused on the impacts and risks associated with water use (i.e. concerns related to water quantity). However, water pollution and other water quality concerns are equally important in companies' assessment of impacts and risks. Pollution can lead to increased incidence of disease; damaged ecosystems; and the inability of people, agriculture, and industry to use that water at all. Future water accounting must give higher priority to measuring corporate wastewater discharge, assessing its impact on ecosystems and communities, and understanding ambient water quality in the watersheds in which they or their supplier's operates. Outside of LCA which has well-developed methodologies for assessing water quality impacts, the methods reviewed in this analysis do not sufficiently assess water quality. That said, many companies likely have internal proprietary systems that assess water discharge and local water quality.

Pilot testing can advance this practice by exploring LCA as a water quality assessment tool – especially its ability to point companies toward meaningful changes in their water polluting practices and measure improvement - and identifying internal systems that companies can share with others.

5. Harmonized reporting criteria

In addition to improved understanding of water-related impacts and business risks, the ability to effectively report to and communicate with key stakeholders is a key goal for water accounting. Stakeholders' ability to assess this information and guide future corporate water-related practices can be supported through a more consistent approach to reporting, both in terms of one company from location to location and year to year, but also across different companies and industry sectors.

Pilot testing can help this convergence of water reporting practices by identifying water use and impacts metrics that are relatively easy to assess for companies and meaningful for key stakeholders, including consumers, investors, environmental representatives, and affected communities. This process will likely require companies to communicate with one another regarding effective metrics to engage with stakeholders in order to better understand their perspectives and needs.

6. Cooperation among companies

Acknowledging that many companies contribute to water scarcity and pollution and are exposed to many of the same types of water-related risks, there is a great opportunity for companies to share innovative practices, policies, and technologies that can assist in measuring and analyzing their relation to water resources, as well as contributing to sustainable water management in general. For instance, companies can share supplier/facility sustainability guidelines, supplier and watershed data, effective reporting criteria, and accounting approaches.

Pilot testing can provide a chance for companies to cooperate in this manner as it will focus on companies in close geographic proximity, who might be likely to have similar suppliers (in the case they are in the same industry sector) and be located in the same watersheds. For example, pilot testers with shared suppliers can work together to encourage more responsible practice and implement education programs. Pilot testers working in the same watershed can pool resources to collect data regarding the local water context and engage with neighboring communities.

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Appendix A: List of Research Advisory Committee Members

Name	Organization
Representatives from companies	
Emmanuelle Aoustin	Veolia Environnement
Denise Knight	Coca-Cola
Henrik Lampa	H&M
Llorenc Mila-i-Canals	Unilever
Andy Wales	SABMiller
Representatives from international NGOs, institutes, and initiatives	
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Jim Fava	UNEP-SETAC Life Cycle Initiative
Sébastien Humbert	Quantis / ISO Working Group on Water Footprinting
Derk Kuiper	Water Footprint Network
Stuart Orr	WWF International
Frederik Pischke	UN-Water
Brian Richter	The Nature Conservancy
Brad Ridoutt	CSIRO
Other experts	
Jim Christiansen	Danish Standards
Luiz Fernando Cybis	Universidade Federal Do Rio Grande Do Sul
Wang Hongtao	Sichuan University
Atsushi Inaba	AIST-Japan
Annette Koehler	UNEP-SETAC Life Cycle Initiative / ETH Zurich
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Vinod Sharma	Indira Ghandi Institute of Development Research
Ex officio members	
Jason Morrison	Pacific Institute
Gavin Power	UN Global Compact
Guido Sonnemann	UN Environment Programme
Rita Schenck	Institute for Environmental Research & Education
Peter Schulte	Pacific Institute

Appendix B:
Key Players in Corporate Water Accounting

Various organizations and initiatives have attempted to help companies responsibly and comprehensively account for their water use and discharges and to achieve sustainable water management in general. Often these attempts are in the form of developing methodologies that act as a framework for accounting. However, these attempts can also be in the form of online tools, standards, guidance, software, or certification schemes. This section will provide brief descriptions of the organizations and initiatives attempting to advance responsible corporate water accounting through such methodologies and other tools.

Water Footprint Network

The Water Footprint Network (WFN) was launched in order to coordinate efforts between academia, civil society, governments, the private sector, and intergovernmental organizations to further develop and disseminate knowledge on water footprint concepts, methods, and tools. To these ends, WFN engages in the following activities:

- Developing standards (methods, guidelines, criteria) for water footprint accounting, impact assessment, and the reduction/offsetting of related impacts;
- Developing practical tools to support people and organizations interested in water footprint accounting, impact assessment and water footprint reduction and offsetting;
- Providing for, or arranging for third parties to provide for, meetings, publications, education, research and development with regard to the water footprint concept;
- Promoting the communication and dissemination of knowledge about water footprinting;
- Supporting government bodies, international institutions, non-governmental organizations, businesses and other organizations in implementing water footprint accounting and developing a sustainable and fair water policy; and
- Providing advice on the application of the water footprint and by checking and certifying the use of the water footprint.

Global Environmental Management Initiative (GEMI)

The Global Environmental Management Initiative (GEMI) is an organization of companies promoting global environmental and social sustainability through the development and sharing of tools and information. In 2002, GEMI released "Connecting the Drops Toward Creative Water Strategies: a Water Sustainability Tool" that looks at water issues at the company-wide level. In 2007, it released "Collecting the Drops: A Water Sustainability Planner" which provides tools and detailed guidance on water issues at the facility level.

World Business Council for Sustainable Development (WBCSD)

The WBCSD – a business association of roughly 200 global companies with efforts to promote sustainable development - launched its Global Water Tool in 2007. This tool – developed in collaboration with CH2M HILL - allows companies to:

- Compare their water uses (direct operations and supply chain) with water and sanitation availability information on a country and watershed basis,
- Calculate water consumption and efficiency,
- Determine relative water risks in order to prioritize action,
- Create key water GRI Indicators, inventories, risk and performance metrics and geographic mapping.
- Perhaps the most important aspect of this tool is that it – unlike water footprint and LCA methodologies –explicitly assesses the business risks associated with water use and discharge.

Overview of LCA entities (particularly in respect to water accounting)

Whereas the water footprint concept and methodology are housed solely within the WFN and developed by a small number of coordinated players, LCA methods have no single base organization and are developed by a number of entities.

UNEP/ SETAC Life Cycle Initiative

The UN Environment Programme (UNEP) and The Society of Environmental Toxicology and Chemistry (SETAC) - a global non-profit professional society aiming to develop principles and practices for sustainable environmental management – have worked together since 2000 on a partnership known as the Life Cycle Initiative. This initiative aims to:

- Collect and disseminate information on successful applications of life cycle thinking;
- Share knowledge about the interface between Life Cycle Assessment and other tools;
- Identify best practice indicators and communication strategies for life cycle management;
- Provide a basis for capacity building;
- Expand the availability of sound LCA data and methods;
- Facilitate the use of life cycle based information and methods.

In respect to water-related LCA efforts, the UNEP/SETAC Life Cycle Initiative launched a working group on the assessment of water use and consumption within LCA. This group was established to provide companies with a framework with which to develop an LCA indicator for water quantity and quality, integrating this indicator within the ISO 14040, and developing an assessment scheme for water within the LCA framework. It is also working to use this scheme to harmonize how water is addressed within the LCA community.

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Australia's CSIRO has taken an active role in advancing the LCA methodology – specifically on water issues and on other environmental issues. In regard to general LCA work, CSIRO has developed and maintained a database of LCA information, published manuals on the principles and practice of LCA. CSIRO Minerals has recently facilitated the implementation of LCA analyses by mining companies in Australia, which helped these companies assess the implications of different metal production and processing routes on water use and the components of their value chain which have the greatest water-related impacts.

PE International

PE International – the world' largest working group in LCA – develops the world's leading LCA analysis software, GaBi. GaBi provides a universal software tool for quantifying the environmental performance at the organization, facility, process, and product levels. This includes LCA, but also a number of different environmental accounting and analysis systems (e.g. GHG accounting, life cycle engineering, environmental reporting, strategic risk management, etc.). In addition to the GaBi software tool, PE International provides consulting services based on LCA analyses and water footprinting assessments.

Quantis

Quantis (www.quantis-intl.com) is a consulting company providing expertise in life cycle assessment (LCA) and offering solutions for organizations worldwide that are engaged in sustainable development.
Quantis is also one of the leaders in the development of water assessment indicators within LCA, being actively involved in the UNEP-SETAC Life Cycle Initiative's project as well as convening the new ISO standard on water. Quantis has offices in Lausanne (Switzerland), Paris (France), Boston (United States) and Montreal (Canada).

International Organization for Standardization (ISO)

ISO, the world's most recognized standards-making body (including the ISO 14000 Environmental Management series) is the developer of the most widely used standards for the implementation of LCA (i.e. the ISO 14040 series).
These ISO standards on LCA describes the principles and framework for LCA including the definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements. This standard provides a framework for a general LCA analysis and does not include water-specific elements.
ISO is currently developing a standard for the principles, requirements, and guidelines for the measurement and communication of the water footprint of products, processes, and organizations. While this standard refers to itself a standard for "water footprints", it is important to note that "water footprints" in this context refers to the broader range of water accounting tools and not specifically water footprints as developed by WFN. This standard intended to establish a framework and set of principles that enable existing water accounting methods to be consistent with one another and with other standards. This

will consider regional concerns (e.g. relative scarcity, extent of economic development, etc.). ISO has explicitly stated that it does not intended to establish its own methodology, but rather provide guidelines for the important elements that water accounting methods should address.

Other corporate water accounting initiatives

Australian Bureau of Meteorology's Water Accounting Standards Board

As part of the Australian Government's Raising National Water Standard Program, the Water Accounting Standards Board (WASB) is responsible for the oversight and coordination of the development of all the nation's standards on water accounting. It is housed with the Bureau of Meteorology, but serves as an independent expert advisory board. WASB recently published the Water Accounting Conceptual Framework (WACF), which provides guidance for the preparation and presentations of general purpose water accounts, as well as a preliminary Australian water accounting standard that is meant to harmonize the methods and indicators that are used to measure water use and discharge. These documents are applicable to many different sectors, including the private sector.

Beverage Industry Environmental Roundtable (BIER) Water Footprint Working Group

BIER – a coalition of global beverage companies working to advance environmental stewardship – has formed the BIER Water Footprint Working Group to develop sector-specific guidelines for assessing the water use and impacts of a company or product. These guidelines will attempt to establish common water accounting boundaries, definitions, and calculation methods for the beverage industry. They will provide detailed instructions for specific inputs and operations that are unique to the sector. These guidelines will be developed with assistance from ISO, WFN, WWF, and UNEP/SETAC and will be published in late 2010.

Corporate Water Gauge

The Corporate Water Gauge™ is a context-based measurement tool/method that measures the sustainability of a facility's and/or enterprise's water use in light of locally relevant watershed and precipitation conditions, while taking into account the volumes, sources and sinks of water inflows and outflows, and the populations with whom such resources must be shared. The Gauge produces quantitative scores that reflect the sustainability of a facility's/organization's water use relative to locally renewable supplies. Sustainability performance is determined by comparing rates of water use against rates of water regeneration, after allocating shares of available resources to specific facilities and/or organizations. It uses GIS technology to profile, analyze and report local hydrological, demographic and economic information at a watershed level of analysis in combination with site-specific datasets. It was developed by the Center for Sustainable Innovation, a non-profit corporation dedicated to the advancement of sustainability measurement, management and reporting in organizational settings.

Minerals Council of Australia

The Minerals Council of Australia (MCA) is an organization - composed of over 60 member companies and associate members – that represents Australian mining and mineral processing industries in their efforts to reach sustainable development. It works to promote policy and practice that is safe, profitable, environmentally sustainable, and socially responsible. Since 2005, MCA has been developing a water accounting framework meant specifically for the mineral industry. This framework aims to provide a way to quantify water flows into and out of facilities, metrics for reporting about water use and discharge, an approach to account for recycled water, and a model for detailed operational water balances. A preliminary framework was released in July 2008 and results from a pilot test of the framework were released in November 2009.

Other supporting organizations and initiatives

Alliance for Water Stewardship

The AWS is an initiative developing a global freshwater stewardship certification program. This certification program will provide a voluntary "eco-label" that rewards responsible water use management with competitive advantage. Such a certification system will require quantification of water use, discharge, and impacts, however the Alliance intends to build on existing methodologies (namely the water footprint as developed by WFN) as a key component of its measurement, and will attempt to minimize duplication of efforts and confusion in this space. The Alliance intends for this certification scheme to be applicable both to water "users" (businesses) and water "providers" (utilities). The initiative is currently in the standards development phase in which they are defining what constitutes water stewardship.

Global Footprint Network

The Global Footprint Network (GFN) - established in 2003 - encourages and facilitates the use of the Ecological Footprint (EF) in order to promote global dialogue and action on ecological limits and sustainability. It is comprised of individuals, cities, nations, companies, scientists, NGOs, and academia from all over the world. The Network's work involves continuously improving the EF methodology, engaging with national governments to establish the EF as a globally-accepted metric, developing footprint standards, and encouraging cooperation among sectors to advance these concepts.

Global Reporting Initiative

The Global Reporting Initiative (GRI) is a network-based organization that has developed the world's most widely-used corporate sustainability reporting framework. The most recent version of this framework (known as the G3 Guidelines) includes five water-related criteria among a list of environmental, social, and economic criteria. These guidelines do not call for the reporting of quantified impacts. They also do not provide a comprehensive methodology for accounting for their criteria, but rather establish a harmonized framework through which companies communicate to stakeholders.

The Greenhouse Gas Protocol Initiative

The GHG Protocol – a partnership between the World Resources Institute and the WBCSD - is perhaps the most popular accounting tool for GHG emissions worldwide. It works with the public, private, and civil society sectors to advance credible and effective programs for mitigating climate change. The GHG Protocol developed the only widely-accepted methodology for corporate carbon footprinting and is one of the many methodologies for product carbon footprinting. It provides the standard for corporate carbon accounting as well as calculation tools for carrying this out. ISO has adopted the Protocol's Corporate Standard as the basis for its standard on corporate carbon accounting.

Appendix C: Acronyms

CDP – Carbon Disclosure Project

CSIRO – Commonwealth Scientific and Industrial Research Organization

CSR – Corporate Social responsibility

DALY – Disability Adjusted Life Year

EF – Ecological Footprinting

FAO – Food and Agriculture Organization

EPD – Environmental Product Declarations

GEMI – Global Environmental Management Initiative

GHG – Greenhouse Gas

GRI – Global Reporting Initiative

IPCC – Intergovernmental Panel on Climate Change

ISO – International Organization for Standardization

LCA – Life Cycle Assessment

LCI – Life Cycle Inventory

LCIA – Life Cycle Impact Assessment

RAC – UNEP-CEO Water Mandate Corporate Water Accounting Research Advisory Committee

SETAC – The Society of Environmental Toxicology and Chemistry

SME – Small and Medium Enterprises

UNEP – United Nations Environment Programme

UNGC – United Nations Global Compact

WBCSD – World Business Council on Sustainable Development

WaFNE – UNEP Water Footprint, Neutrality, and Efficiency Umbrella Project

WF – Water Footprinting

WFN – Water Footprint Network

WFDSS – Water Footprint Decision Support System

WFSA – Water Footprint Sustainability Assessment

WRI – World Resources Institute

WRM – Water Resources Management

WTO – World Trade Organization

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Jason Morrison
Peter Schulte

Mapping Initiatives on Corporate Water Disclosure

June 2009

UNEP

The CEO Water Mandate

Global Reporting Initiative™

PACIFIC INSTITUTE

Preface

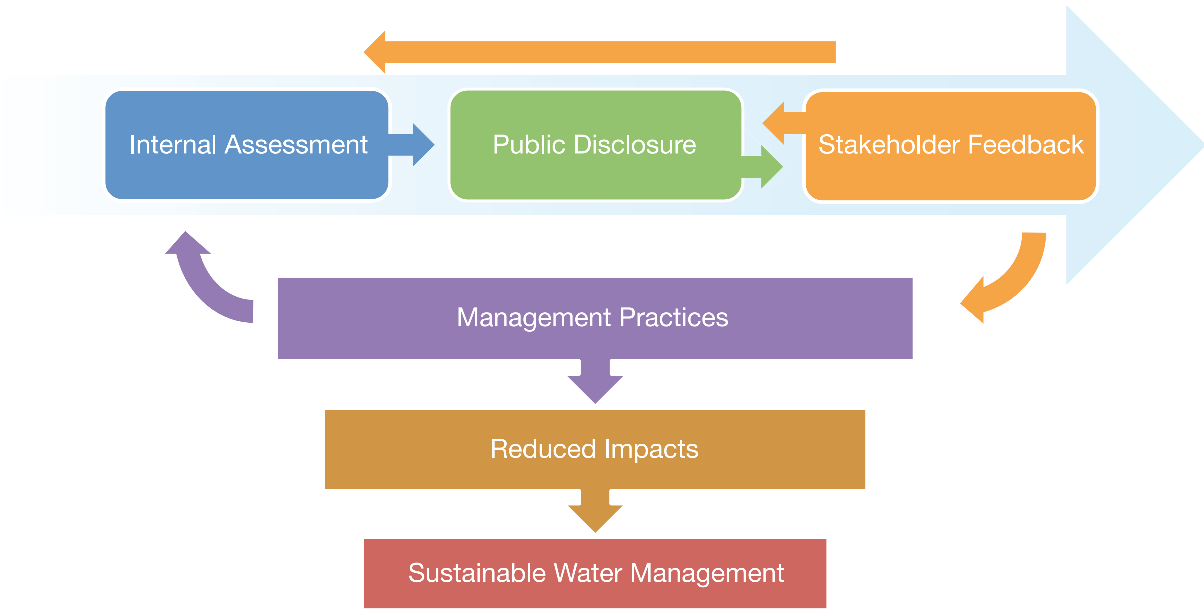
UNEP has commissioned The CEO Water Mandate Secretariat and Global Reporting Initiative (GRI) to conduct a cursory mapping of various initiatives working to progress the public disclosure of water-related information in the private sector. Authored by the Pacific Institute (as part of the CEO Water Mandate Secretariat), this mapping exercise examines roughly a dozen initiatives from industry, civil society organizations, the UN, and the investment community. It briefly explores each initiative's primary work area(s) or niche(s) with regard to water disclosure, along with a description of key objectives and past and prospective work in the field.

The mapping will be presented and discussed at a July 2009 meeting in London featuring representatives from these major water initiatives in order to elucidate: 1) each initiative's primary focus areas, 2) the overlaps in current and prospective workstreams, and 3) the critical gaps no initiative is addressing, among other things. This meeting will attempt to reach consensus on what needs to be managed/measured and the roles that various entities are trying to play in relation to water disclosure. The London meeting's outcomes will be further discussed at the Mandate's Fourth Working Conference to be held at World Water Week in Stockholm in August 2009 in the hopes that it will inform the Mandate's future work plans on water disclosure.

Conceptual Overview

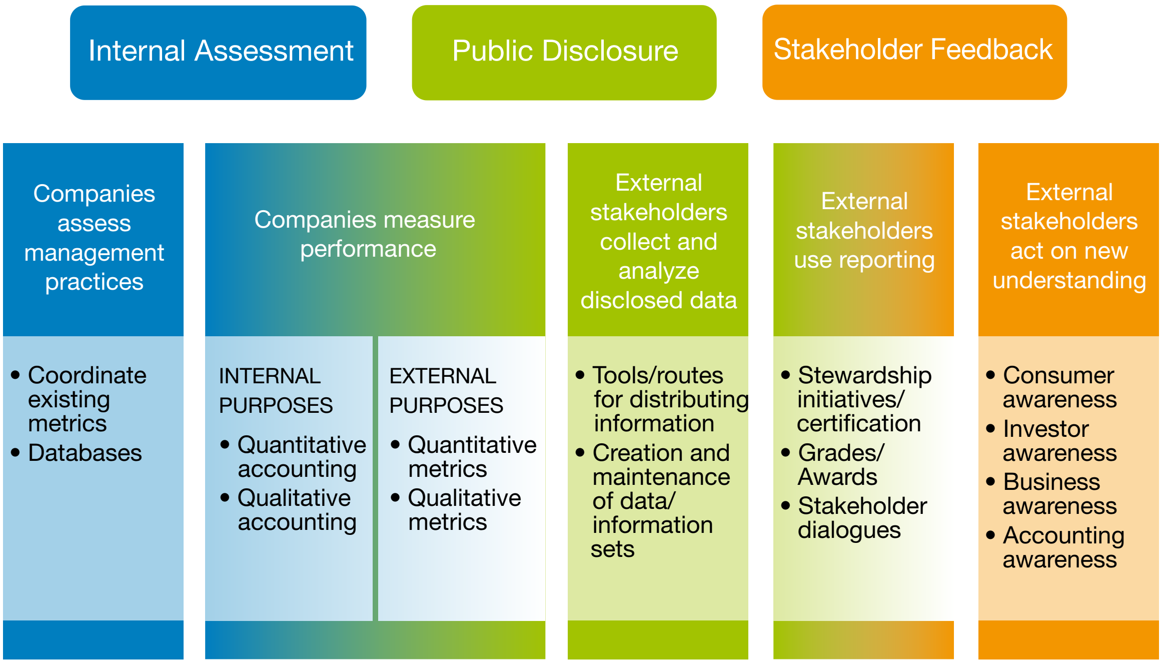
The goal of the Coordination Meeting on Corporate Water Disclosure is to bring together the community of initiatives working on corporate water disclosure to build a common view of the needs around disclosure and determine ways to make our collective work most effective. In doing so, we may consider the following questions/concepts to guide our discussion:

Framework: Is there a broadly recognized need for more and improved disclosure on corporate water performance? If so, what is a functioning and effective system ("framework") for filling this need? To help stimulate an answer to this question, we have provided a draft framework below (i.e. the loops between internal assessment, public disclosure, stakeholder feedback, and management practices) to understand one idea of how disclosure enacts change. Presumably, given the participating initiative's workstreams on disclosure, this will be a relatively easy question to answer.



Actions: What actions – in support of this broad framework - are necessary for water disclosure to serve as an effective driver of improved water management and performance? This discussion will parse the broader framework components into specific, concrete steps that need to occur to move from the measurement of information to its application and use by stakeholders, and eventually to improved corporate management practices. One way these actions could be conceived is provided below. We may want to consider the following:

- What happens at each step in the framework?
- What sub-categories of steps are needed to support these actions?
- Who are the types of actors needed to perform each step/action (e.g. companies, NGOs, investors, research agencies?)



Leverage Points / Stakeholders: What stakeholders (both groups providing output and their intended audiences) will be most effective at and have the greatest impact on each individual action? This is a theoretical discussion on how to maximize stakeholders groups and the demand and resources they generate. This topic is perhaps the most complex/difficult as it mixes the questions of tactics and purpose. At one level, we must ask which stakeholders will be effective push/pull factors for these actions. At another level, we must ask what type of content will be emphasized at each concrete step/action. In regard to leverage points, we might ask:

- How many distinct disclosure audiences do we wish to address? Consumers? Investors? Professional stakeholders (e.g. NGOs, research institutes, etc.)? More?
- Do the needs of any one stakeholders shape the needs of one of the tools? How do different audiences affect the content needed at each step?
- Can we have multiple channels for disclosure that are aimed at specific audiences without interfering with each other and diluting impact?

Tools/Initiatives: What are the various roles that existing tools/initiatives seek to play in relation to the actions outlined above? How can we optimize these efforts? Unlike the previous theoretical topic regarding leverage points, this conversation seeks to analyze actual current activities to determine how existing initiatives can align most effectively. The purpose of this question is to identify how various existing tools, guidance, and initiatives align with our framework/set of actions and leverage points. A draft of how this might look is provided below. Possible questions on this topic include:

- What is the function that each initiative seeks to serve?
- What are the leverage points that each initiative seeks to use?
- Are there any overlaps in intended roles among existing initiatives?
- Which initiatives have the potential to directly feed into each other and maximize the effectiveness of the system as a whole?

Companies assess management practices	Companies measure performance		External stakeholders collect and analyze disclosed data	External stakeholders use reporting	External stakeholders act on new understanding
RISK ASSESSMENT • Ceres/PI report • WRI "Watching Water" • WRI water risk index IMPACT ASSESSMENT • WFN DSS • LCA • WBCSD Measuring Impact Framework	INTERNAL QUANTITATIVE ACCOUNTING • WBCSD Global Water Tool • WFN • LCA QUALITATIVE ACCOUNTING • CEO WM guide for process oriented reporting	EXTERNAL QUANTITATIVE METRICS • GRI G3 • UN-Water water sector indicators • CDP Water Disclosure Module QUALITATIVE METRICS • CEO WM guide for process oriented reporting • CDP risk disclosure framework	TOOLS/ROUTES FOR DISTRIBUTING INFORMATION • CDP pilot project • CEO WM "Water Disclosure 2.0" • ICCR "Liquid Assets" • UNWater "Water Monitoring" CRATION AND MAINTENANCE OF DATA/INFORMATION SETS • ICCR "Data Commons"	STEWARDSHIP INITIATIVES/ CERTIFICATION • AWS • WFN • CEO WM GRADES/AWARDS • GRI G3 • ACCACeres Sustainability Awards STAKEHOLDER DIALOGUES • Ceres • WEF • CEO WM	CONSUMER AWARENESS • CDP Water Disclosure Project INVESTOR AWARENESS • GRI G3 • Ceres/PI report BUSINESS AWARENESS • ICCR business engagement • WFN business engagement • WBCSD ACCOUNTING AWARENESS • ACCA "Water Jigsaw"

Measurement needs: While beyond the scope of discussions of the Coordination Meeting on Corporate Water Disclosure (due to limited time), eventually the indicators we need to measure must be discussed. Who uses these indicators and how? This topic concerns the "ecosystem" of indicators (not captured in our mapping) needed to make disclosure comprehensive and efficient, rather than the set of tools/initiatives discussed above. Determining measurement needs will lead us to ask:

- Why are we seeking to gather and disclose data about companies and water? To measure efficiency? Risk? Impact?
- At what geographic levels do measurements need to occur? Site-level? Regional level? Group-level? Other?
- How do corporate indicators relate to other types of indicator sets, such as national indicators?
- How do these various systems overlap and what are common themes/measures for each level?
- What is the content which we are measuring in each case?
- What is needed to make these measurement approaches useable and feasible?

Alliance for Water Stewardship (AWS)

Primary focus area(s) on corporate water disclosure: Standards/certification system for water stewardship

Key objectives:

1. Create international freshwater stewardship standards covering direct and indirect impacts of water use, applicable to large water users and managers
2. Establish certification system to reward responsible water stewards
3. Oversee certification system

Past work:
Since it began work in 2008, AWS has focused on: defining 'water stewardship'; testing the concept with stakeholders; building its team of partners from various sectors, areas of expertise, and geographic diversity; as well as on developing the standards. The standards development process has been comprised of private meetings among AWS partners and multi-stakeholder workshops meant to garner input from various geographic regions and stakeholders. The certification system is not yet operational.

Current and prospective work:
Complete standards development
AWS's primary current workstream is developing the water stewardship standards upon which the certification system will be centered. The initiative will continue holding multi-stakeholder workshops and will conduct pilot testing of the draft standards in various sectors and geographic regions. AWS hopes the initial standard(s) will completed by 2010.

Draft standards include indicators on water stewardship that are intended to align with existing GRI indicators on water. This standard will also likely require public communication including possibly:

- Reporting on the organization's five-year objectives and targets on water,
- Disclosing the organization's water stewardship indicators annually,
- Summarizing the objectives and results of its water stewardship program in a publicly available report every five years.

Relevant URLs:
1. AWS official website
2. AWS Fact Sheet

Association of Chartered Certified Accountants (ACCA)

Primary focus area(s) on corporate water disclosure: Sustainability reporting awards

Key objectives:

1. Reward companies based on sustainability reporting performance
2. Raise awareness of sustainability issues amongst the accounting community

Past work:
Water: The Next Carbon?
In April 2009, WWF-UK and ACCA partnered to release a six-page discussion paper outlining the key global water issues and steps companies can take to mitigate related risks, including water footprinting.

ACCA-Ceres Sustainability Reporting Awards
ACCA and Ceres provide awards annually for companies exhibiting exceptional sustainability reporting, based on transparency, how well the companies communicate their performance, and to what degree their reports provide evidence of the integration of sustainability issues reported. ACCA and Ceres give a best overall report award as well as several individual awards, including one for best report in the water sector, but otherwise do not specifically address water.

Current and prospective work:

Research on corporate water disclosure

ACCA and WWF-UK have recently signed an MOU to collaborate on ACCA's UK Awards for Sustainability Reporting 2009 research. This program will specifically assess the standard of corporate disclosure on water use and management and develop sector-specific criteria to analyze CSR reports' water-related content.

"Water Jigsaw"

ACCA plans to coordinate experts in the fields of water impact assessment and footprinting, water accounting, water law, water reporting, and future focus areas into a group that will educate ACCA members on these issues through a series of papers. These papers will pull together existing materials on these topics as a way of help members and other stakeholders understand the current and emerging concepts. These papers will ultimately be compiled into one document, known as the "Water Jigsaw".

Relevant URLs:

1. Water: The Next Carbon?
2. 2008 ACCA-Ceres Sustainability Reporting Awards results

Carbon Disclosure Project (CDP)

Primary focus area(s) on corporate water disclosure: Research/tools development for water reporting

Key objectives:

1. Collect corporate water-related data relevant to global climate change
2. Analyze this data to develop framework for companies to better disclose water data
3. Generate stakeholder 'pull' for disclosure – investors to request from quoted companies, customers to request from suppliers

Past work:

CDP 2009: 3700 quoted companies globally requested to disclose on behalf of 475 investors; 2000 suppliers requested to disclose on behalf of 54 customers; no specific water disclosure request

Pilot project on disclosure of water-related risks:

In 2008, the CDP Supply Chain program pilot-tested a module for corporate water disclosure completed by 15 companies across a variety of sectors. The pilot module surveyed companies on three primary issues: 1) Water-related Risks and Opportunities, 2) Water accounting, and 3) Water management. Rather than focusing on quantitative data, CDP's pilot attempted to determine companies' understanding of and capabilities regarding:

- Water-related risks for their business and supply chains,
- Water-related aspects on climate change,
- The depth and breadth of their (and their suppliers') water accounting,
- Their knowledge of the hydrologic context of their business operations and supply chain,
- Corporate-level and facility-level water management plans.

Current and prospective work:

- Further develop water-related risk disclosure framework
- Issue report on pilot program – July 09
- Incorporate module as optional part of CDP Supply Chain 2009
- Major IT upgrade will allow addition of disclosure projects/modules on other subjects
- Launch Water Disclosure Project in 2010 or 2011 for investor community along the same lines as CDP, using same IT platform and back-office processes for speed/low cost implementation. Target 50 institutional investor signatories and top 200-300 corporates in water-intensive sectors

Relevant URLs:

1. Report on CDP 2009 Consultation Workshop

The UN Global Compact's CEO Water Mandate

Primary focus area(s) on corporate water disclosure: (1) Research/tools development for water reporting, (2) convening stakeholders to understand and develop current and emerging practice

Key objectives:

1. Scope "state of play" of current corporate water disclosure practices
2. Convene major corporate players and stakeholders to discuss water disclosure projects
3. Develop guidance for qualitative water reporting and materiality assessment,

Past work:

Transparency Framework:

The Mandate's Transparency Framework describes general expectations for corporate disclosure on water-related issues and establishes transparency policies, objectives, and activities deemed valuable and credible by endorsing companies and a range of stakeholders.

Phase I of this framework (released October 2008) set out to:

- Delineate the basic expectations of the CEO Water Mandate Secretariat regarding minimum transparency-related responsibilities of endorsers,
- Lay out the broad architecture regarding how this unique Mandate element can be conceptualized and operationalized within the initiative.

Phase II of this framework (released March 2009) set out to:

- Illustrate various forms of reporting approaches and contents, highlighting good practices and innovative approaches,
- Identify commonalities, differences, and gaps among water reports,
- Present the findings in a way that can serve as de facto guidance for corporate reporting.

Transparency Policy

The Mandate also developed a set of disclosure requirements for its endorsing companies that stipulate that Mandate endorsers companies must report their progress in implementing the Mandate's six elements annual, including a statement of continued support, description of policies and practical actions taken, and measurement of outcomes or expected future outcomes.

Current and prospective work:

- Develop guidance for *qualitative* water reporting, with a focus on the Mandate's "process€oriented" elements.
- Build methods and guidance to promote better understanding of materiality and the sustainability context in which water€related reporting occurs.

Relevant URLs:

1. The official Mandate website
2. Transparency Framework Phase I
3. Transparency Framework Phase II
4. Transparency Policy

Ceres

Primary focus area(s) on corporate water disclosure: Research on water-related business risks

Key objectives:

1. Educate and inform investors and companies on the financial risks posed by water availability and quality issues
2. Improve the quality of corporate reporting on water-related risks
3. Leverage the investor community to support improved corporate stewardship of water resources

Past work:

Water Scarcity & Climate Change: Growing Risks for Businesses & Investors

Ceres, in collaboration with the Pacific Institute, produced a report in 2009 highlighting the linkages between business risks form water scarcity and climate change. This report made a business case for companies to more comprehensively address water issues and provided a framework of key questions which companies and their investors can use to better understand and address water-related risks.

Workshops on Water-Energy Nexus and Corporate Sustainability Reporting
In April 2009, Ceres convened workshops featuring representatives from civil society, business, and the investment community that explored: 1) the business risks and opportunities inherent in water and energy use, as well as the interconnectivity between these issues and 2) the current status of corporate sustainability reporting. These workshops were intended to share knowledge of these issues across various sectors and interests.

Ceres-ACCA's Sustainability Reporting Awards
ACCA and Ceres provide awards annually for companies exhibiting exceptional sustainability reporting, based on transparency, how well the companies communicate their performance, and to what degree their reports provide evidence of the integration of sustainability issues. The 2008-2009 Ceres-ACCA "Report of the Judges" included a special section highlighting the lack of meaningful water-related reporting among North American submissions and key aspects of water risk disclosure sought out by the awards' judging panel.

Current and prospective work:
Assessment of Water Risk Disclosure in SEC Filings & CSR Reports
Ceres is in the early stages of developing a report that assesses the current state of water-related disclosure by (primarily U.S. domiciled) companies in water-intensive sectors. The report will highlight the frequency and nature of water risk disclosures made in the SEC filings and CSR/sustainability reports of the largest publicly-traded companies in 7-8 water-intensive sectors. The report would seek to elevate investor and company awareness about the state of water risk disclosure, identify key trends and possible gaps.

Relevant URLs:
1. Water Scarcity & Climate Change: Growing Risks for Businesses & Investors
2. Ceres-ACCA 2008 North American Sustainability Reporting Awards "Report of the Judges"

Global Reporting Initiative (GRI)

Global Reporting Initiative

Primary focus area(s) on corporate water disclosure: Sustainability reporting guidance/principles/indicators

Key objectives:
1. Develop a set of principles, standard disclosures, and indicators, including water-specific items, that comprise corporate social and environmental responsibility
2. Implement these principles, standard disclosures, and indicators into a framework for corporate sustainability reporting
3. Build capacity for companies to utilize this framework

Past work:
G3 Guidelines
GRI's primary workstream is the development of comprehensive frameworks for corporate sustainability reporting. These guidelines are meant to provide metrics on a variety of sustainability issues through which companies can better understand material issues and further harmonize their CSR reports with other companies'. Each GRI performance indicator is supported by a technical protocol of approximately 1-2 pages in length. These protocols provide standard definitions and high-level guidance on compilation/calculation methods for preparing and reporting data in sustainability reports.
The latest version of this framework, called the G3 Guidelines, incorporates more indicators on water use and discharge than any previous guidelines.

GRI Sector Supplements
GRI also develops industry-specific guidelines for reporting. Where appropriate, these supplements may also include further sector-specific indicators on water.

GRI Water Protocol for 2002 Guidelines
GRI developed a protocol on water indicators meant to provide definition and clarifications of the terms, concepts, and expectations outlined in the predecessor guidelines (G2) to the G3. This protocol was designed in order to improve understanding among reporting companies and consumers alike. The Water Protocol has not been updated to align with the G3 Guidelines.

Prospective work:
GRI is planning to undertake work to provide guidance for organizations on how to improve the utility of their disclosures of water performance data. At this point in time, GRI has not received feedback pointing to a need to change its indicators that relate to measuring the water footprint of any organization. However, it has received feedback that raw data aggregated to a global level has limited value for users and fails to articulate how water use is material to an organization and its stakeholders. It is planning to undertake a project to identify ways to better disaggregate data and present in a sustainability context that helps demonstrate the materiality of the data to report users. GRI also plans to explore the possible overlap between its work and footprinting/impact indicators work, as well as the possibility of coordinating with these groups.

Relevant URLs:
1. GRI G3 Guidelines (including water-specific indicators)
2. GRI Water Protocol

Interfaith Center on Corporate Responsibility

Primary focus area(s) on corporate water disclosure: Development of widely-accepted accountability measures for monitoring and reporting corporate water use and for benchmarking corporate progress toward an "ethical water footprint."

Key objectives:
1. Recognition of water as a human right and acting in accordance with existing human rights policy that acknowledges right to life, health, and livelihoods
2. Operational practices consistent with corporate responsibility and good stewardship of the water commons, using the company's significant resources.
3. Procedures that respectfully engage the community in order to secure both social and legal license to operate.
4. Verified reporting of comprehensive data for each water stressed areas of operation
5. Publicly accessible data that can be used by all stakeholders via the Internet

Past work:
Direct corporate engagement on water
ICCR has engaged a variety of companies to encourage the adoption of the above objectives. Companies engaged include Coca-Cola, PepsiCo, Hormel Foods, Intel, IBM, and Barrick Gold, among others. The engagement of ICCR's faith-based members with PepsiCo played a pivotal role in the company's adoption of a policy on the human right to water in 2009. ICCR has also participated in meetings of the CEO Water Mandate and is a member of River Network, a U.S. association of over 500 local clean water activists.

The Global Water Crisis
This 2004 report provides background information on the unfolding crisis of freshwater availability and expected impacts of climate change on water resources.

Current and prospective work:
Liquid Assets: Responsible Investment in Water Services
This report, to be released in July 2009, surveys performance data on environmental, social, and governance (ESG) issues publicly disclosed by drinking water and sanitation utilities. It includes two government-owned and operated water utilities and ten investor-owned utilities. It aims to assess the comprehensiveness, consistency, and comparability of data reported by water utilities for their operations in various geographic regions and management schemes.

For the 2009-2010 proxy season, ICCR will engage companies in the agricultural commodities, beverage, food, water services, electric power, coal, oil, and gas sectors regarding their monitoring and reporting their water footprint. Our long term goal is the creation of a "data commons" for water, using existing Internet platforms that can be accessed by investors, civil society organizations, and local watershed monitors.

Relevant URLs:

1. ICCR website

Pacific Institute

PACIFIC INSTITUTE

Primary focus area(s) on corporate water disclosure: Research on "state of play" of and emerging practice on corporate water reporting

Key objectives:

1. Map "state of play" of corporate water disclosure across various business sectors, highlighting commonalities and gaps
2. Explore and articulate the business risks/ opportunities associated with water scarcity and the justification for improved water disclosure

Past work:

Corporate Reporting on Water

Prior to its 2009 analysis of water reporting for The CEO Water Mandate, the Pacific Institute conducted a similar stand-alone study in 2007, evaluating how a sample of 139 companies recognize, address, and report their water-related risks and practices.

Water Scarcity & Climate Change

The Pacific Institute, in collaboration with Ceres, produced a report in 2009 highlighting the linkages between business risks form water scarcity and climate change. This report made a business case for companies to more comprehensively address water issues and provided a framework of key questions which companies (and investors) can use to better understand their water-related risks and report them to investors and other stakeholders.

Current and prospective work:

It is anticipated that future water disclosure work by the Pacific Institute will be carried out within the Institute's capacity as the "operational arm" of the CEO Water Mandate Secretariat.

Relevant URLs:

1. "Corporate Reporting on Water"
2. Water Scarcity & Climate Change: Growing Risks for Businesses & Investors
3. At the Crest of a Wave: A Proactive Approach to Corporate Water Strategy

UN-Water

Primary focus area(s) on corporate water disclosure: Water sector monitoring and reporting, Indicator development to provide coherent and reliable data and information on trends in the water sector

Key objectives:

1. Harmonize water sector monitoring at the global level to improve reporting of performance;
2. Develop methodology for monitoring *water sector* progress and performance, including a set of measurable indicators for both national decision-makers and the international community,
3. Facilitate "developing countries" in adapting proposed *water sector* monitoring methodology in terms of how the information should be collected, analyzed and reported.
4. Assess "indicators, monitoring, and databases' in regards to the world's freshwater issues in order to incorporate this into the World Water Development Reports (WWDR).

Past work:

"Water Monitoring: Mapping Existing Global Systems and Initiatives"

In 2006, UN-Water released a report mapping of water-related monitoring activities. It reviewed concepts and definitions related to water monitoring, developed criteria to describe and analyze monitoring activities, designed a framework for classifying activities, and determined issues for action.

Roundtable discussion on water indicators
In early 2009, the WWAP Expert Group (EG) on Indicators, Monitoring, and Databases held a meeting of 12 representatives from the private sector, policy development, and major water use sectors to discuss the water indicators needed. The group focused on: the state of the resource, water uses, and the interface between the resource and its uses and governance and performance.

Current and prospective work:
UN-Water Task Force – Phase One
The TF is carrying out a participatory process for selecting "policy domains" and "key indicators" for the water sector. The TF will suggest ways to improve data collection, monitoring, and reporting for these indicators and identify areas lacking data or in need of new approaches. A common framework for global monitoring and reporting in the water sector will be presented in Stockholm in August 2009. The TF will also produce a "short-list" of water sector indicators with survey procedures and computational methods, among other things. A second phase of the TF may look at a long-term program for improved "harmonization" and "country support" at global and country levels to inform the developed indicators.
Expert Group – Consultations on current state of global water indicators and ways forward
The EG will discuss which goals discussed at the 2009 roundtable are achievable with data providers and interpreters. It will also determine complementary conclusions to bridge the gap between water users and providers. These conclusions will be synthesized within the fourth WWDR, which will show progress on the flow of data between different sectors, users, and providers. UN-Water is currently starting the process of preparing for the next WWDR, which will take into consideration the work of the EG and TF.

Relevant URLs:
1. Task Force website
2. Water Monitoring: Mapping Existing Global Systems and Initiatives
3. Meeting summary of Expert Group's January 2009 consultation

Water Footprint Network (WFN)

Water Footprint

Primary focus area(s) on corporate water disclosure: Standardized Water footprint methods and tools
Key Objectives related to water disclosure:
1. Develop and advance the concept of the 'water footprint' to promote better quantitative corporate water disclosure
2. Increase the water footprint awareness and quantitative water disclosure of businesses and their understanding of how consumption of goods and services and production chains relate to water use and impacts on fresh-water systems;
3. Encourage forms of water governance that reduce the negative ecological and social impacts of the water footprints of businesses.

Past work:
Having been established in late 2008, WFN has recently started implementing its work program, building on the water footprint methodology, data and statistics and tools previously developed by the Professor Arjen Hoekstra from the University of Twente.

Prospective work:
The Water Footprint Network undertakes the following concrete activities:
1. Developing standards (methods, guidelines, criteria) for water footprint accounting, footprint impact assessment and the reduction and offsetting of the negative impacts of footprints;
2. Developing practical tools to support people and organizations interested in water footprint accounting, impact assessment and water footprint reduction and offsetting;
3. Providing meetings, publications, education, research and development on the water footprint,
4. Promoting the exchange, communication, and dissemination of knowledge about footprints,
5. Supporting government bodies, international institutions, non-governmental organizations, businesses and other organizations in implementing water footprint accounting and developing a sustainable and fair water policy,
6. Providing advice on the application of the footprint and checking and certifying its use.

Water Footprint Decision Support System (DSS)
As part of its work program, the WFN plans to develop a Water Footprint DSS - an interactive software-based system designed to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions. The WFDSS is intended to answer four major questions:

- What is the size of my water footprint in terms of both water quantity and quality?
- What is the condition (baseline and current) of the watersheds where water footprints occur?
- What are the impacts of my water footprint in the watersheds?
- What are the available response strategies to reduce my water footprint and improve the water quantity or quality conditions in the watersheds?

Relevant URLs:
1. On Corporate water footprints
2. A comprehensive introduction to water footprints

World Business Council for Sustainable Development (WBCSD)

Primary focus area(s) on corporate water disclosure: Business tools for water management

Key objectives:
1. Produce tools to support integration of water issues into corporate strategic planning,
2. Document experiences in corporate water management outside direct business operations,
3. Share best practice on water management across business sectors.

Past work:
WBCSD Global Water Tool
WBCSD launched a tool in 2007 to help companies map their water uses and assess water-related risks in relation to the hydrologic contexts of their global operations and supply chain. This tool allows companies to assess which operations and suppliers are located in water-scarce countries or watersheds. It aims to establish a company's relative water risks in order to prioritize current and future actions, create a knowledge base for driving improved water consumption and efficiency, and enable more effective communication with internal and external stakeholders.

Measuring Impact Framework
In March 2008, WBCSD released its Measuring Impact Framework allowing companies to assess their impacts on the economic and broader development goals of the societies where that business operates, which could include increased access to water and sanitation services.

Corporate Ecosystem Services Review
Launched jointly with WRI in March 2008, the review consists of a five-step methodology that helps managers develop strategies to address risks and opportunities linked to companies' dependence and impacts on ecosystems, including freshwater.

Current and prospective work:
Engagement in the Water Footprint Network (WFN)
As a founding partner (and member of its Supervisory Council), WBCSD aims to provide collective and cross-sectoral business input into the development of standards, tools and guidelines on water use measurement and impacts assessment.

Water for Business: Initiatives Guiding Sustainable Water Management in the Private Sector
WBCSD and IUCN are developing an overview of major business initiatives addressing the challenge of better defining sustainable water management through different approaches, including guidelines, tools, measurement methodologies, as well as communication and stewardship schemes. It will help business identify which initiatives and approaches will most suit their needs, and to help developers of schemes to understand opportunities for increasing impact through consensus building and joint action.

Relevant URLs:
1. WBCSD Water website
2. WBCSD Measuring Impact Framework
3. WBCSD Global Water Tool
4. WBCSD Water Scenarios to 2025
5. WBCSD / WRI Corporate Ecosystem Services Review

World Economic Forum (WEF)

Primary focus area(s) on corporate water disclosure: Reporting harmonization/methodology

Key objectives:

1. Harmonization of water disclosure methodology,
2. Development of universal indicators for water management,
3. Collection of various corporate water management activities.

Past work:

Since 2005, WEF Water Initiative has focused on establishing multi-stakeholder regional networks in South Africa and India in order to catalyze ideas for public-private water infrastructure projects. More recently, WEF has worked closely on agricultural water use and water policy reform, paying particular attention to risk mitigation strategies and support for governments in water-scarce regions.

WEF's major workstreams regarding water disclosure began in 2008, and as such it has provided few deliverables to date. Preliminary ideas for water disclosure harmonization tools were presented at Davos 2009. They have also released a report examining different economic and geopolitical scenarios if current water management activities continue, addressing businesses role in water stewardship, however it did not touch on water disclosure.

Current and prospective work:

Harmonization of water disclosure methods

WEF does not appear to have a concrete plan for improving harmonization of water disclosure methods, however it will convene a public-workshop to discuss this and various other issues in Q3 2009.

Mapping of corporate water management activities

WEF hopes to create a resource tool to capture a comprehensive collection of corporate efforts on water management. This will include an interactive website and discussion platform to host information on water initiatives and partnerships and a tool that would enable stakeholders to access this information and input into corporate water management activities, including disclosure.

Relevant URLs:

1. WEF Water Initiative website
2. Water Initiative at a Glance
3. Annual Meeting 2009 Fact Sheet
4. Future Water Needs Report

World Resources Institute (WRI)

Primary focus area(s) on corporate water disclosure: (1) Promoting understanding of sector-specific water risks and opportunities among mainstream investors, (2) develop a standard approach to accounting for such risks.

Key objectives:

1. Sector and region-specific sector studies (mostly with financial institutions)
2. Tools for disclosure of water risks in a way that is meaningful and useful to mainstream investors.

Past work:

"Watching Water: A Guide to Evaluating Corporate Risks in a Thirsty World"

JPMorgan, with support from WRI, released a report in 2009 providing a framework for investors to evaluate impacts from water scarcity and pollution for sectors and individual companies. This report explores various water-related business risks and opportunities, providing criteria for examining those issues to be used by companies to promote communication to investors and other stakeholders.

"The Greenhouse Gas Protocol Corporate Accounting and Reporting Standard"

In 2004, WRI and WBCSD released a standard for accounting and reporting systems for greenhouse gas (GHG) emissions. The standard provides a protocol and guidance for companies and other organization preparing a GHG emissions inventory meant to promote understanding of emissions, reduce costs, provide information that can be used to create an effective business strategy, and ultimately increase transparency and understanding of corporate GHG emissions by consumers and investors.

“Watering scarcity - private investment opportunities in agricultural water use efficiency”
In this report by Rabobank, WRI helped explore how different trends (notably higher energy and commodity prices, policy reforms) provide new opportunities for scaling up investments in efficient irrigation technology and practices.

Prospective work:
“Treating water - Sector report for engagement: Water exposure of food & beverage companies”
In this report, WRI considers awareness, disclosure, and management of water risks among ten food and beverage companies and develops an 8-step agenda for corporate engagement.

Sector study and water risk index:
A study with Goldmand Sachs and GE of water constraints in power generation, which will likely focus on China’s power-hungry, but water-stressed Yellow River basin. The intent is to build a water risk index for the specific combination of sector/technology and river basin. That water risk index will then be generalized into a water risk framework for investors as a standard approach towards accounting for different water risks (re. GHG protocol), also in other sectors and regions.

Relevant URLs:
1. Watching Water: A Guide to Evaluating Corporate Risks in a Thirsty World
2. The Greenhouse Gas Protocol Corporate Accounting and Reporting Standard

About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

> sustainable consumption and production,

> the efficient use of renewable energy,

> adequate management of chemicals,

> the integration of environmental costs in development policies.

The Office of the Director, located in Paris, coordinates activities through:

- **The International Environmental Technology Centre** - IETC (Osaka, Shiga), which implements integrated waste, water and disaster management programmes, focusing in particular on Asia.
- **Sustainable Consumption and Production** (Paris), which promotes sustainable consumption and production patterns as a contribution to human development through global markets.
- **Chemicals** (Geneva), which catalyzes global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.
- **Energy** (Paris), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.
- **OzonAction** (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.
- **Economics and Trade** (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies.

UNEP DTIE activities focus on raising awareness, improving the transfer of knowledge and information, fostering technological cooperation and partnerships, and implementing international conventions and agreements.

As water resources are unevenly distributed and, in some regions scarcity and droughts are increasing both in frequency and intensity due to climate change, concerns about them are also becoming more and more important on the international agenda.

In this context, the UNEP project called "Water Footprint, Neutrality and Efficiency" (WaFNE) addresses the growing need to further enhance water efficiency and to improve water quality in a comprehensive way, in water-intensive industries and water-stressed areas, especially in the developing countries.

This report provides an overview on the public and private initiatives as well as methods and tools for water accounting and efficiency worldwide with the aim of raising awareness and enhancing sustainable water management.
The report includes three documents developed by UNEP in the area of water footprint and corporate water accounting and disclosure for resource efficiency:

1. "Water footprint assessment, policy and practical measures in a specific geographical setting". UNEP and Water Footprint Network.

2. "Corporate Water Accounting - An Analysis of Methods and Tools for Measuring Water Use and its Impacts". UNEP and UN Global Compact CEO Water Mandate with the Pacific Institute.

3. "Mapping Initiatives on Corporate Water Disclosure". UNEP, the CEO Water Mandate and the Global Reporting Initiative.

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Water Footprint

Global Reporting Initiative

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