UNESCO-IHE
Institute for Water Education

A.Y. Hoekstra

March 2008

Water neutral:

reducing and offsetting the impacts of water footprints

Value of Water

Research Report Series No. 28

WATER NEUTRAL:

REDUCING AND OFFSETTING THE IMPACTS OF WATER FOOTPRINTS

*A.Y. HOEKSTRA**

MARCH 2008

VALUE OF WATER RESEARCH REPORT SERIES NO. 28

* Twente Water Centre, University of Twente

e-mail: a.y.hoekstra@utwente.nl

The Value of Water Research Report Series is published by
UNESCO-IHE Institute for Water Education, Delft, the Netherlands
in collaboration with
University of Twente, Enschede, the Netherlands, and
Delft University of Technology, Delft, the Netherlands

Contents

Summary

During the past few years the concept of the 'water footprint' has started to receive recognition within governments, non-governmental organizations, businesses and media as a useful indicator of water use. The increased interest in the water-footprint concept has prompted the question about what consumers and businesses can do to reduce their water footprint. 'Water neutrality' is a concept that can be instrumental in this context. The aim of this report is to critically discuss the water-neutral concept. It first discusses the water-footprint concept, because water neutrality is all about reducing and offsetting the impacts of water footprints.

The water footprint is an indicator of water use that looks at both direct and indirect water use. The water footprint of a product (good or service) is the volume of fresh water used to produce the product, summed over the various steps of the production chain. The water footprint of a consumer is the sum of its direct water use, i.e. the water used at home or in the garden, and its indirect water use, i.e. the water used in the production and supply chains of the goods and services consumed. The water footprint of a business consists of its direct water use, for producing, manufacturing and supporting activities, plus its indirect water use, i.e. the water used in the business's supply chain. 'Water use' is measured in terms of water volumes consumed (evaporated) and/or polluted. The 'water footprint' includes three components: consumptive use of rainwater (green water), consumptive use of water withdrawn from groundwater or surface water (blue water) and pollution of water (grey water). A water footprint can be calculated for any product or activity as well as for any well-defined group of consumers (e.g. an individual or family, or the inhabitants of a village, city, province, state or nation) or producers (e.g. a public organization, private enterprise or a whole economic sector). A water footprint is more than a figure for the total water volume used; it refers specifically to the type of water use and where and when the water was used.

'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. 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 use cannot be nullified. Therefore 'water neutral' generally does not mean that water use 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 and invites for positive action. 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?

In the current state of development, the weakness of the concept is that it can still be adopted to be used in a multitude of different meanings, so that in the end it becomes an empty, meaningless concept, losing its potential to effectively bring about positive change. The greatest threat is therefore that major players in the global community do not manage to arrive at consensus on the precise definition of the concept, creating room for dilution of the concept, which reduces its potential to promote positive action.

Despite the possible pitfalls and yet unanswered questions, it seems that the water-neutral concept offers a useful tool to bring stakeholders in water management together in order to discuss water footprint reduction targets and mechanisms to offset the environmental and social impacts of residual water footprints. However, the concept can become really effective in actually contributing to wise management of the globe's water resources only when clear definitions and guidelines will be developed. There will be a need for scientific rigour in accounting methods and for clear (negotiated) guidelines on the conditions that have to be met before one can speak about water neutrality. Undoubtedly there will be a great market for water-neutrality and water-offsetting, comparable to the market for carbon neutrality and offsetting, but the extent to which this market will become effective in contributing to a more efficient, sustainable and equitable use of the globe's water resources will depend on the rules of the market. Without agreed definitions and guidelines on what is water neutrality, the term is most likely to end up as a catchword for raising funds for charity projects in the water sector. In that context, the term can also fulfil a useful function, but it would be 'water neutrality' in its weakest form. It will become a strong concept only when claims towards water-neutrality can be measured against clear standards.

1. Introduction

Various human activities consume or pollute a lot of water. At a global scale, most of the water use occurs in agricultural production, but there are also substantial water volumes consumed and polluted in the industrial and domestic sectors (Postel et al., 1996). Water consumption and pollution are generally associated with specific activities, such as irrigation, bathing, washing, cleaning, cooling and processing. Total water consumption and pollution are generally regarded as the sum of a multitude of independent water demanding and polluting activities. There has been little attention to the fact that, in the end, total water consumption and pollution relate to what and how much communities consume and to the structure of the global economy that supplies the various consumer goods and services. In the science and practice of water management there has been hardly any thought about the water consumption and pollution along whole production and supply chains. As a result, there is little awareness about the fact that the organisation and characteristics of a production and supply chain does actually strongly influence the volumes (and temporal and spatial distribution) of water consumption and pollution that can be associated with a final consumer product. Recently, Hoekstra and Chapagain (2008) have shown that visualizing the indirect water use behind products can help in understanding the global character of fresh water and in quantifying the effects of consumption and trade on water resources use. The improved understanding can form a basis for a better management of the globe's freshwater resources.

Fresh water is increasingly becoming a global resource. Apart from regional markets, there are also global markets for water-intensive goods like crop and livestock products, natural fibres and bio-energy. As a result, water resources use has often become spatially disconnected from the consumers. This can be illustrated for the case of cotton. From field to end product, cotton passes through a number of distinct production stages with different impacts on water resources. These stages of production are often located in different places and consumption can happen at yet another place. For example, Malaysia does not grow cotton, but imports raw cotton from China, India and Pakistan for processing in the textile industry and exports cotton clothes to the European market (Chapagain et al., 2006). As a result, the impacts of consumption of a final cotton product on the globe's water resources can only be found by looking at the supply chain and tracing the origins of the product. Uncovering the hidden link between consumption and water use creates room for new strategies for better water governance, because new triggers for change can be identified. Where final consumers, retailers, food industries and traders in water-intensive products have traditionally been out of the scope of those who studied or were responsible for good water governance, these players enter the picture now as potential 'change agents'. They can be addressed now not only in their role as *direct* water user, but also in their role as *indirect* water user.

The idea of looking at whole production and supply chains in order to assess the total environmental impact that can be associated with a final product and to identify ways to reduce the impact is not new. This is precisely what is done in the field of 'life cycle assessment' (LCA). However, LCA studies have focussed on materials and energy use along supply chains; relatively little attention has been paid to water use (Ayres and Ayres, 1998, 1999). The idea of considering water use along supply chains has gained interest after the introduction of the 'water footprint' concept (Hoekstra, 2003; Hoekstra and Chapagain, 2007, 2008). The water footprint is an indicator of water use that looks not only at direct water use of a consumer or producer, but also at the indirect water use.

During the past few years the water footprint has started to receive recognition as a useful indicator of water use, within both governments (UNESCO, 2006) and non-governmental organizations (Zygmunt, 2007; WWF, 2008), as well as within businesses (WBCSD, 2006; JPMorgan, 2008) and media (The Independent, 2008; The Economist, 2008; Discover Magazine, 2008). The increased interest in the water-footprint concept has prompted the question about what consumers and businesses can do to reduce their water footprint. Several instruments have been proposed, including a water label for water-intensive products, an international water-pricing protocol, an international business agreement on water-footprint accounting, and a Kyoto-protocol-like agreement on tradable water-footprint permits (Hoekstra, 2006; Verkerk et al., 2008). Another concept that has been proposed is that of 'water neutrality'. The idea behind the concept is to see whether humans can somehow neutralise or offset their 'water footprint'. The question is very general and interesting from the point of view of both individual consumers and larger communities, but also from the perspective of governments and companies.

The aim of this report is to critically discuss the water-neutral concept. It first discusses the water-footprint concept, because water neutrality is all about reducing and offsetting the impacts of water footprints (Figure 1.1). Subsequently, the report elaborates the idea of water neutrality. After a generic discussion of the concept, it is discussed what water neutrality means for a product, an individual consumer or a business. Finally, the concept is critically analysed in terms of its strengths and weaknesses.

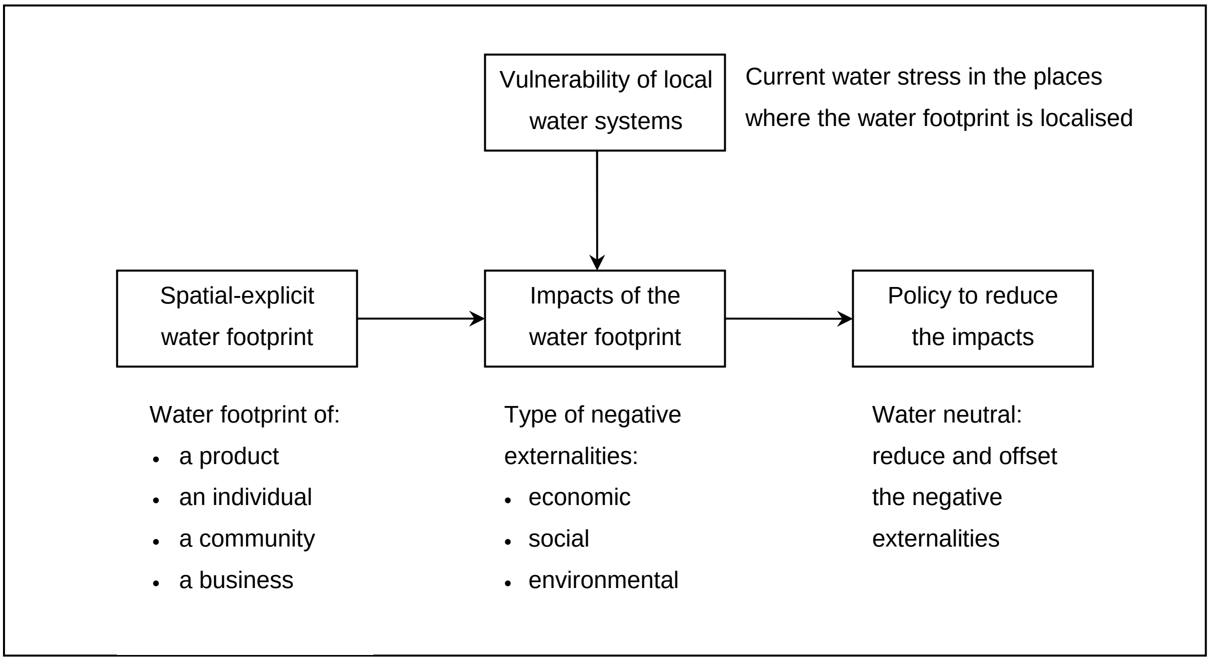

Figure 1.1. From water footprint accounting to impact assessment and policy formulation.

2. The water-footprint concept

2.1 Introduction

The water footprint is an indicator of water use that looks at both direct and indirect water use. The water footprint of a product (good or service) is the total volume of fresh water used to produce the product, summed over the various steps of the production chain. The water footprint of an individual or community is the total volume of fresh water used by the individual or community in direct or indirect way. The indirect water use refers to the water that is used to produce the goods and services consumed by the individual or community. The water footprint of a business consists of its direct water use in its own operations plus its indirect water use, i.e. the water use in the business's supply chain. 'Water use' is measured in terms of water volumes consumed (evaporated) and/or polluted. A water footprint can be calculated for any product or activity as well as for any well-defined group of consumers (e.g. an individual or family, or the inhabitants of a village, city, province, state or nation) or producers (e.g. a public organization, private enterprise or a whole economic sector). A water footprint is more than a figure for the total volume of water used; it refers specifically to the type of water use and where and when the water was used.

The concept of the water footprint shows similarity to the concepts of the ecological footprint and the carbon footprint (see Box 2.1). The roots and intended purposes of the three concepts differ, however (Hoekstra, 2007). The roots of ecological footprint analysis lie in the search for an indicator that can show what proportion of the globe's biocapacity has been appropriated. The carbon footprint was formulated later to be able to quantify the contribution of various activities to climate change. The roots of water footprint analysis lie in the exploration of the global dimension of water as a natural resource. The starting point was the discontent with the fact that water resources management is generally seen as a local issue or a river-basin issue at most. The fact that international trade affects the global pattern of water use has been overlooked. The global dimension of water resources management and the relevance of the structure of the global economy have been ignored by most of the water science and policy community (Hoekstra, 2006). In addition, the production (supply) perspective in water resources management is so dominant that it is hardly recognised that water use relates in the end to human consumption. By looking at the water use along production and supply chains, the water footprint aims to uncover this hidden link between human consumption and water use.

The idea of the water footprint builds on the concept of 'embedded water' or 'virtual water' that was earlier introduced by Allan (1998) when he studied the option of importing virtual water (as opposed to real water) as a partial solution to problems of water scarcity in the Middle East. Allan elaborated the idea of using virtual-water import (coming along with food imports) as a tool to release the pressure on the scarcely available domestic water resources. Virtual-water import thus becomes an alternative water source, alongside endogenous water sources. Imported virtual water has therefore also been called 'exogenous water'. In fact, the concept is similar to concepts like embodied energy, land or labour, so that one could also speak about 'embodied water'. The interest in virtual water started to grow rapidly once the first quantitative studies were published (Hoekstra and Hung, 2002; Hoekstra, 2003; Chapagain and Hoekstra, 2004; Oki and Kanae, 2004; De Fraiture et al., 2004).

Hoekstra and Chapagain (2008) define the 'virtual-water content' of a product (good or service) as the volume of fresh water used to produce the product, summed over the various steps of the production chain. The adjective 'virtual' refers to the fact that most of the water used to produce a product is not contained in the product. The real-water content of products is generally negligible if compared to the virtual-water content. 'Virtual-water flows' occur when water-intensive products are traded from one place to another (Figure 2.1) or when products move through a supply chain (Figure 2.2). The 'virtual water content' of a product is the same as what is called the 'water footprint' of a product in this report. The term 'water footprint', however, is broader, in the sense that the water-footprint concept gives a spatial and temporal dimension to the concept of 'virtual water content'. In this way, the water footprint offers a link to impact assessment and policy formulation.

Box 2.1: Three dimensions of the human footprint.

The water-footprint concept is part of a larger family of concepts that have been developed in the environmental sciences over the past decade. A 'footprint' in general has become known as a quantitative measure showing the appropriation of natural resources by human being. The ecological footprint is a measure of the use of bio-productive space (hectares). The carbon footprint measures energy use in terms of the volume of carbon dioxide emissions (in tonnes). The water footprint measures water use (in cubic metres).

In the mid-1990s, Rees and Wackernagel (1994) developed the concept of the 'ecological footprint'. Their concern was to quantify the amount of space required to supply the world population with what they consume. People need land for living and moving, agricultural land (cropland and pasture) to produce the food required and forestland to supply things like wood and paper. Finally, there is forestland needed to transform the carbon dioxide emitted by human activities into organic matter. It has been argued that the total ecological footprint of all world inhabitants together can temporarily go beyond the available area, but only by exhausting the natural resource base, which is considered 'unsustainable'. Humanity has moved from using, in net terms, about half the planet's biocapacity in 1961 to 1.25 times the biocapacity of the Earth in 2003 (Hails et al., 2006). The global ecological deficit of 0.25 Earths is equal to the globe's ecological overshoot.

The carbon footprint is an indicator of the impact that human activities have on the global climate and is expressed in terms of the amount of greenhouse gases produced. It is an indicator for individuals and organizations to conceptualize their personal or organizational contribution to global warming. The carbon footprint refers to the total amount of CO_2 and other greenhouse gases emitted over the full life cycle of a product or service. A carbon footprint is usually expressed as a CO_2 equivalent (in tonnes), in order to make the global warming effects of different greenhouse gases comparative and addable.

The water footprint of an individual, community or business is expressed in terms of a volume of fresh water used per year. The water footprint of a product is expressed as the volume of fresh water used per unit of product. 'Water use' means here that the water is either evaporated or polluted, so that it is no longer available in its original state and cannot be readily reused[1]. The focus on fresh water is important because fresh water is scarce, not water in general. The volume of fresh water on earth is only 2.5% of the total amount of water on

[1] The water footprint is a first-order indicator of human's interference in the water cycle. By measuring evaporation and pollution, it shows the immediate impact on a local water system. The water that has been appropriated and then lost to the atmosphere or the water that has become polluted is not available to the natural system that it did sustain. Also it is not available to immediate use for a human purpose again. It is recognized that evaporated water remains within the hydrological cycle and thus will return at some time at some point and that polluted water may get clean again through natural purification processes. Since water is a renewable resource, it can be appropriated but not depleted as in the case of a non-renewable resource.

earth (Gleick, 1993). A water footprint consists of three components: the blue, green and grey water footprint. The blue water footprint refers to the volume of 'blue water' (surface or ground water) that has been evaporated as a result of its appropriation for human purposes. It excludes the part of the water withdrawn from the ground or surface water system that returns to that system directly after use or through leakage before it was used. The green water footprint refers to the volume of 'green water' (rainwater stored in the soil) that has been evaporated as a result of its appropriation for human purposes. The grey water footprint is the volume of polluted water that associates with the production of goods and services. It 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.

Water footprints are defined based on the actual water use per unit of product, not on the basis of global average numbers. This means that water footprints can only be calculated by analysing the source of products and considering the actual water use in the countries of origin (where production takes place).

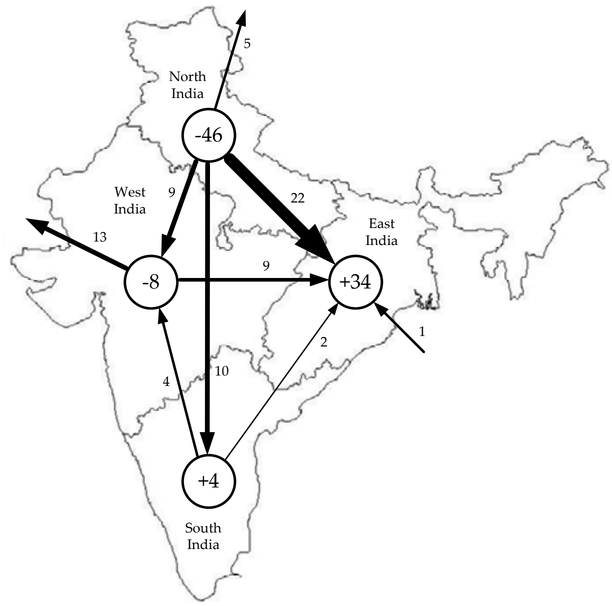

Figure 2.1: An example of interregional virtual-water flows. The map shows net virtual-water flows within India due to trade in agricultural products. Flows and balances in billion m^3/yr. Period 1997-2001. Source: Kampman et al. (2008).

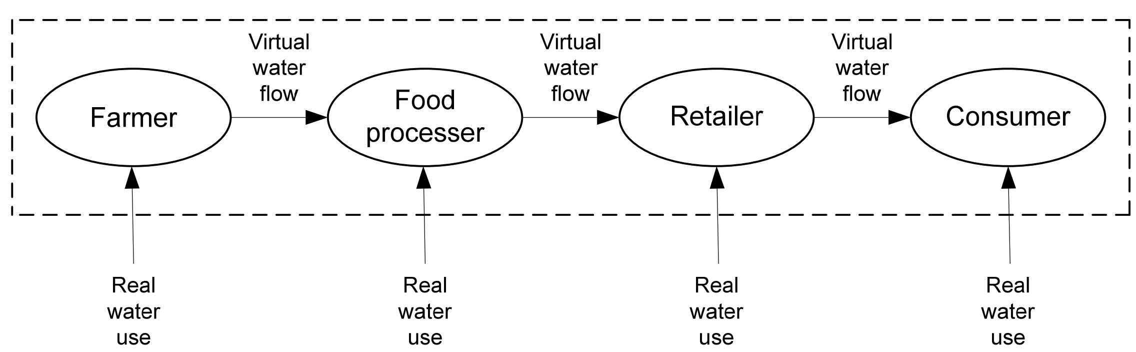

Figure 2.2. The virtual-water chain.

The water footprint is another indicator of water use than 'water withdrawal', the classic water-use indicator generally found in statistics. It differs from the classic indicator in three respects. First, the water footprint refers to consumptive water use (the water that evaporates), while the indicator of 'water withdrawal' includes non-consumptive water use (return flows) as well. Second, the water footprint measures not only blue water use (as the classic indicator of water withdrawal), but also green water use and the production of polluted grey water (Figure 2.3). Third, the water footprint measures total water appropriation of goods and services by integrating water consumption and pollution over the complete production and supply chain. In other words, the water footprint includes direct and indirect water use, while the indicator of water withdrawal refers to direct water use only. By adopting the supply-chain perspective, the water footprint maps the link between locally consumed or produced products and global appropriation of water resources, something that the classic indicator cannot do.

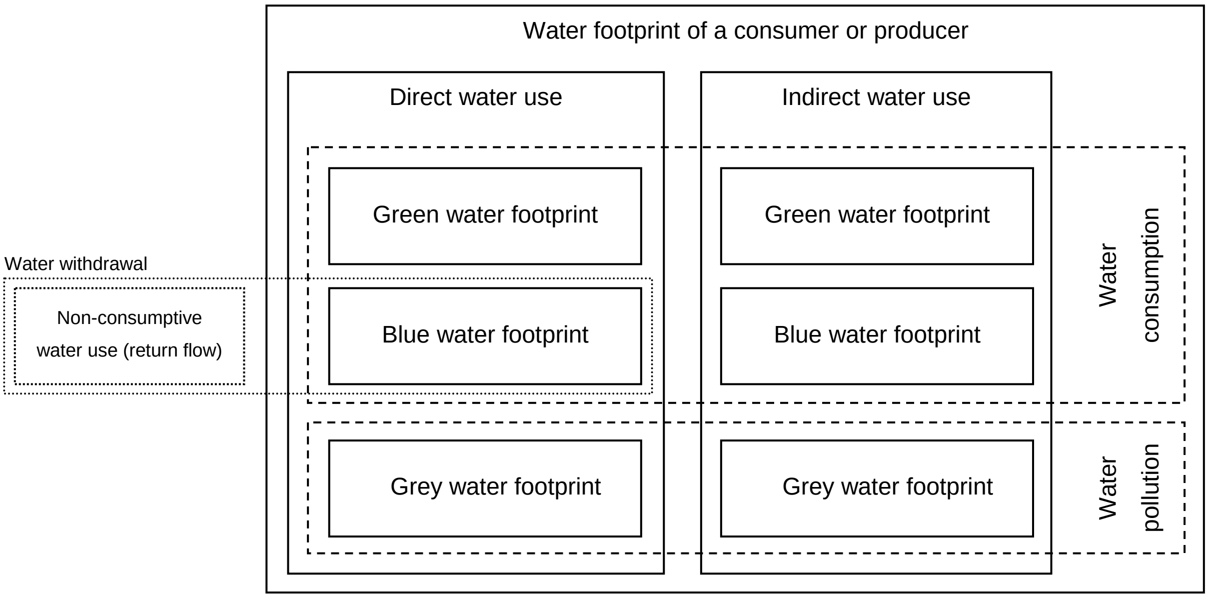

Figure 2.3. Schematic representation of the components of a water footprint. It shows that the non-consumptive part of water withdrawals (the return flow) is not part of the water footprint. It also shows that, contrary to the measure of 'water withdrawal', the 'water footprint' includes green and grey water and the indirect water-use component.

2.2 The water footprint of a product

The water footprint of a product is defined as the total volume of fresh water that is used directly or indirectly to produce the product. It is estimated by considering water use in all steps of the production chain[2]. The accounting procedure is similar to all sorts of products, be it products derived from the agricultural, industrial or

[2] It is recognized that water use connected to a product is not limited to its production stage. In the case of many products (e.g. a washing machine) there is some form of water use involved in the use stage of the product. This component of water use, however, is not part of the product water footprint. The water use during product use is included in the water footprint of the consumer of the product. Water use in the reuse, recycle or disposal stage of a product is included in the water footprint of the business or organisation that provides that service and is included in the water footprints of the consumers that benefit from that service.

service sector[3]. Below, the accounting procedure is discussed in a bit more detail for products derived from crops and livestock.

The water footprint of primary crops (m^3/ton) can be calculated as the crop water use at field level (m^3/ha) divided by the crop yield (ton/ha). The crop water use depends on the crop water requirement on the one hand and the actual soil water available on the other. Soil water is replenished either naturally through rainwater or artificially through irrigation water. The crop water requirement is the total water needed for evapotranspiration under ideal growth conditions, measured from planting to harvest. 'Ideal conditions' means that adequate soil water is maintained by rainfall and/or irrigation so that it does not limit plant growth and crop yield. The crop water requirements of a certain crop under particular climatic circumstances can be estimated with crop models like the one developed by the Food and Agriculture Organization (FAO, 2008). Actual water use by the crop is equal to the crop water requirement if rainwater is sufficient or if shortages are compensated through irrigation. In the case of rainwater deficiency and the absence of irrigation, actual crop water use is equal to effective rainfall. When a primary crop is processed into a crop product (e.g. paddy rice processed into brown rice), there is often a loss in weight, because only part of the primary product is used. In such a case the water footprint of the processed product can be calculated by dividing the water footprint of the primary product by the so-called product fraction. The product fraction denotes the weight of crop product in tons obtained per ton of primary crop (Hoekstra and Chapagain, 2008). If a primary crop is processed into two or more different products (for example soybean processed into soybean flour and soybean oil), one needs to distribute the water footprint of the primary crop amongst its products. One can do this proportionally to the value of the crop products. When during processing there is some water use involved, the process water is added to the water footprint of the root product (the primary crop) before the total is distributed over the various root products. In a similar way one can calculate the water footprint for products that result from a second or third processing step. The first step is always to obtain the water footprint of the input (root) product and the water used to process it. The total of these two elements is then distributed over the output products, based on their product fraction and value fraction.

The water footprint of live animals can be calculated based on the water footprint of their feed and the volumes of drinking and service water consumed during their lifetime. As input data one needs to know the age of the animal when slaughtered and the diet of the animal during its various life stages. The calculation of the water footprint of livestock products (like meat, leather, milk, cheese and eggs) can again been based on product fractions and value fractions, following the method described above.

2.3 The water footprint of an individual or group of consumers

The water footprint of an individual or group of consumers consists of two components: the direct water use, i.e. the water use at home or in the garden, and the indirect water use, i.e. the water use in the production and supply

[3] Sometime people speak about agricultural goods, industrial goods and services, but this may be a bit confusing, because production of so-called industrial goods will generally involve inputs from the agricultural and service sectors, etcetera.

chains of the goods and services consumed. The indirect water use can be estimated by multiplying all products (goods and services) consumed by their respective product water footprint.

The water footprint of a community is equal to the sum of the individual water footprints of its members. There is no double counting due to the fact that the water footprints of private goods are exclusively allocated to the consumer of the private good, while the water footprints of public goods or services are allocated to individuals based on the share that each individual takes. The total water footprint of humanity is equal to the sum of the individual water footprints of all inhabitants of the world, which is also equal to the sum of the water footprints of all final consumer goods and services consumed annually.

2.4 The water footprint of a business

One can also assess the water footprint of producers, be it a single producer, a company or a whole economic sector (Gerbens-Leenes and Hoekstra, 2008). The WBCSD (2006) expects that in due time governments will ask large businesses to account for their water footprints. The water footprint of a business is defined here as the total volume of fresh water that is used directly or indirectly to run and support a business. This water footprint can be assessed by looking at both the direct water use, i.e. the producer’s water use for manufacturing or for supporting activities, and the indirect water use, i.e. the water use in the producer’s supply chain. The water footprint of a business thus includes two components: the operational and the supply-chain water footprint. Both components potentially break down again into a green, blue and grey water footprint.

Many businesses in the industrial or service sector will typically have a supply-chain water footprint that is larger than its operational water footprint. Particularly when a company does not have agricultural activity itself but is partly based on the intake of agricultural products (crop products, meat, milk, eggs, leather, cotton, wood/paper), the supply-chain water footprint will generally be much larger than the operational water footprint. In the supply-chain water footprint green water will often be dominant, while in the operational water footprint it will be blue or grey water. Also in the bio-industry a business water footprint will be dominated by its supply-chain component, because the water volume used for making the feed (the bio-industry’s supply chain) is much larger than the water volumes used for operating a bio-industry (drinking, cleaning, pollution). For crop farms, however, the operational water footprint will be much larger than the supply-chain water footprint. If we roughly describe the economic system as a chain that goes from agricultural production and mining through manufacturing and retailing to consumption, we see that direct water use intensities gradually decline.

By definition, the water footprint of a business is equal to the sum of the water footprints of the business output products. The supply-chain water footprint of a business is equal to the sum of the water footprints of the business input products. Obviously, the water footprint of one business can overlap with the water footprint of another business. The supply-chain water footprint of a retailer for example will partly overlap with the water footprints of its suppliers. This is important to recognize, because if businesses decide to take up the challenge to reduce their water footprints (or the water footprints of their products), they we will have shared responsibilities.

2.5 The impact of a water footprint

The impact of a water footprint at a certain location at a certain point in time will depend on a variety of factors, including the availability of water resources at the location considered, the level of local competition between various water users, the local “environmental flow requirements” and the “assimilation capacity” of the local water system. A moderate level of freshwater consumption in a region with low water availability can have a higher impact on the environment (e.g. biodiversity) than a higher level of water consumption in a water-abundant region. The impact of water consumption at a certain location also depends on the environmental flow requirements because these requirements as a fraction of monthly or annual runoff are higher in some rivers than in others (Smakhtin et al., 2004). Finally, local water systems differ in what they can assimilate, because degradation rates for specific chemicals vary depending on various conditions, so that the effect of chemicals disposed into ground or surface water systems will not be similar everywhere. In other words: the impact of a certain water footprint depends on the vulnerability of the region where the water footprint is located (see Figure 1.1).

As shown by Van Oel et al. (2008), the impact of a water footprint can be estimated by overlaying the global water-footprint map with a global water-stress map. Hotspots – i.e. places where the impact of the water footprint is relatively large – appear where both the water footprint and the vulnerability of the local water system are relatively large. The impact of water consumption or pollution at a certain location is obviously larger when the volume of water consumption or pollution is relatively substantial and when local water scarcity is relatively high as well. Figure 2.4 gives an example of a hotspot map, showing the water-footprint hotspots related to the Dutch consumption of agricultural products.

The impacts of a water footprint can be economic, social or environmental. The water footprint associated with a certain product can have a negative economic impact when the marginal cost of the water is not fully charged to the user. In practice, users seldom pay the full marginal cost of water, which reflects the sum of investment costs, operation and maintenance costs, a scarcity rent and economic externalities. As a result, existing water use patterns are often not efficient from an economic point of view. Environmental impacts of water consumption and pollution include damage to local ecosystems and biodiversity. Social impacts of water consumption and pollution include impacts on public health and social equity issues that arise when some users apply a lot of water while other people do not have access to a minimum.

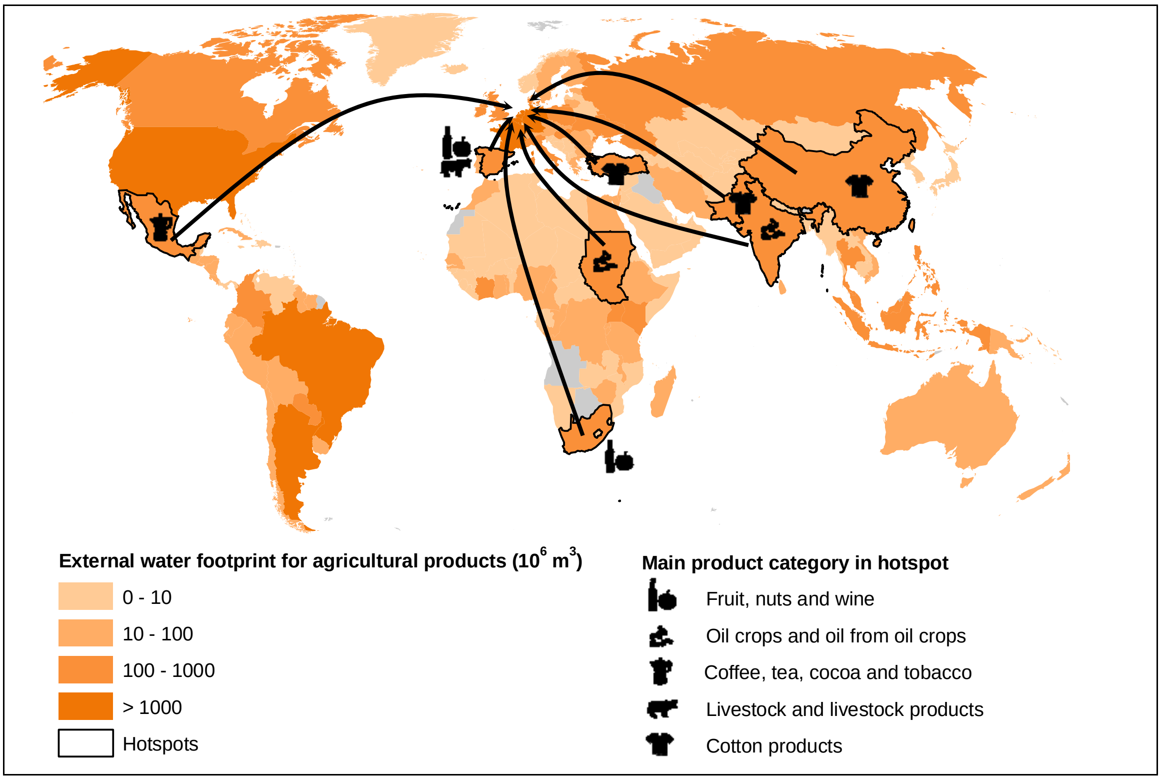

Figure 2.4. An example of a water footprint impact map. In different shades of orange, the map shows the global water footprint related to the Dutch consumption of agricultural products. The map further highlights the countries considered as hotspots, i.e. the countries where the water footprint of the Netherlands has relatively high environmental and social impacts. Per hotspot the map shows the most important products that are associated with the Dutch water footprint. Source: Van Oel et al. (2008).

3. The water-neutral concept

3.1 Introduction

The idea of the water-neutral concept is to stimulate individuals and corporations that undertake water-consuming or polluting activities to make their activity 'water neutral' by reducing water consumption and pollution and by compensating for the negative impacts of remaining water consumption and pollution through investing in projects that promote the sustainable and equitable use of water within the environment and community that is affected. Water consumption and pollution can be reduced for example by investing in water saving technology, water conservation measures and wastewater treatment. Compensation for negative impacts can be done for example by investing in improved watershed management or by supporting poor communities that do not have access to clean water to set up and maintain their own water supply system.

The water-neutral concept was conceived by Pancho Ndebele at the 2002 Johannesburg World Summit for Sustainable Development (Water Neutral, 2002). The idea at the time of the Summit was to quantify the water consumed during the conference by delegates and translate this into real money. Delegates, corporations and civil society groups were encouraged to make the summit water neutral by purchasing water-neutral certificates to offset their water consumption during the ten-day summit, with the offset investment being earmarked for the installation of pumps to water needy communities in South Africa and for water conservation initiatives. In 2006 Pancho Ndebele and the author of this report came together to discuss a linkage of the water-neutral and water-footprint concepts. This resulted in the development of a simple water neutral calculator aimed to help visitors to South Africa estimate their water footprint during their stay and calculate the offset price to be paid (Chapagain and Hoekstra, 2007). This calculator is currently being implemented as part of a strategy of the Water Neutral Foundation in Johannesburg to offset the water footprints of visitors to South Africa by selling water offset certificates and thus raising funds to be spent on projects that contribute to a more sustainable and equitable water use in South Africa.

Since about mid-2007, the water-neutral concept is being discussed within various communities, including academia, environmental NGOs and businesses, as a potential tool to translate water footprints into modes of action. A group of stakeholders (representatives from University of Twente, WWF, The Coca Cola Company, Nestlé, Suez, Aquafed, the World Business Council on Sustainable Development and UNESCO-IHE) has had two informal meetings about the concept of water neutrality: in September 2007, at WWF in Zeist, the Netherlands, and in January 2008, at UNESCO-IHE in Delft, the Netherlands. More recently, others have joined the discussions, including the Nature Conservancy and the World Water Council.

The water-neutral concept shows similarity to the carbon-neutral or carbon-offset concept as has been developed in response to the challenge of taking climate change counter-measures. The principle of the concept is that a person reduces his/her water footprint as much as possible and pays a justified amount of money for the residual water footprint that he/she presses on the global water resources. It can be an instrument to raise awareness, stimulate measures that reduce water footprints and generate funds for the sustainable and fair use of freshwater resources.

Now that the water-neutral concept has been discussed in a bit wider audience it has become clear that the concept of water neutrality can be applied in a variety of contexts. In a generic sense, one can say that a good, service, individual consumer, community or business is water neutral when the negative externalities of the water footprint of the good, service, individual consumer, community or business have been reduced and offset.

In order to become ‘water neutral’ there are two requirements. First, all that is ‘reasonably possible’ should have been done to reduce the existing water footprint. Next, the residual water footprint is offset by making a ‘reasonable investment’ in establishing or supporting projects that aim at the sustainable and equitable use of water. The phrases between brackets (reasonably possible, reasonable investment) include normative elements that need further specification and about which one needs to reach consensus. The investment can be made in real terms in the form of own effort, but it can also be in terms of providing funds to support projects run by others. The size of the investment (the offset or payoff price) should be a function of the vulnerability of the region where the (residual) water footprint is located. A certain water footprint in a water-scarce area or period is worse and thus requires a larger offset effort than the same size water footprint in a water-abundant region or period.

Water depletion or pollution in one river basin cannot be neutralised by water saving or pollution control in another basin. Offsetting is to be done within the hydrological unit where the impacts take place. In this respect, the water-offset concept differs from the carbon-offset concept, since for the purpose of CO_2 emission reduction it does not matter where at earth this reduction is achieved.

A consumer or business being requested to offset its (residual) water footprint may ask: why pay an offset price if already a price was paid to get the water? The answer is twofold. First, water users seldom pay the full cost of the water. Sometimes they pay (part of) the investment costs and operation and maintenance costs associated with the supply of the water, but hardly ever they cover the cost associated with the scarcity of the water (a scarcity rent) or the costs associated with negative economic externalities. The offset price is partly to compensate for this under-pricing and can be used to compensate for the external effects and to invest in better water management. Second, there are impacts associated with water consumption and pollution that go beyond the economic costs that need to be compensated: social impacts like unfair water distribution and environmental impacts like biodiversity reduction.

3.2 Water neutrality of a product

The idea of water neutrality of a product or activity can be most easily illustrated in the case of a new, i.e. additional product or activity. In this case one can demand that the water footprint associated with the new product or activity is neutralised by reducing the water footprint of another product or activity by the same size. When in a town, for example, one develops a new district for living or working, one can first make sure that the additional water demand that can be associated with the new district is as small as possible by using construction materials that have a low water footprint, by applying water saving devices in all buildings and by constructing proper wastewater treatment with possibilities for reuse. The remaining water footprint of the new district (the one-time water footprint of all construction activity plus the water footprint in the years to come that will be associated with the activities within the new district) can be neutralised by making an effort to reduce the water footprint in other (old) districts of the town (e.g. by replacing inefficient water distribution systems by more efficient ones or by constructing not-yet existing wastewater treatment plants) to such an extent that effectively the water use in the town remains equal as during the time before the new district was built. This form of water neutrality has been subject of discussion in the UK in the recent past (BfW, 2006; TCPA, 2008). As a concrete example, in November 2006, the UK Government began a study to explore the feasibility of achieving water neutrality in the Thames Gateway, an area of land east of London (EA, 2007). According to this study, water neutrality in the Gateway would be achieved if “the total water used after new development was equal to or less than total water use in the Thames Gateway before the development (in the baseline year of 2005/06).”

In a similar way one can make incidental large events ‘water neutral’. Big conferences (like the earlier mentioned Johannesburg Conference in 2002) or large sports tournaments (like the Olympic Games), that generally have a significant additional impact on local water systems, can be organised in a water neutral way by minimising water consumption and pollution by all possible means and by investing in local water projects aimed at improved management of the water system as a whole and for the benefit of society at large.

The concept of water neutrality can also be applied to existing products or activities. In this case the process towards water neutrality will actually result in a real improvement, contrary to the above examples of new products and activities where water neutrality means maintaining the status quo.

3.3 Water neutrality of a consumer

Individual consumers or communities can try to become water neutral by reducing their water footprint and offsetting their residual water footprint. Reducing water use at home is relatively easy, because the amount of water use at home is under a person’s direct control. The indirect water footprint of a consumer, however, is generally much bigger than the direct water footprint, so that one should also critically consider the water footprints of the various goods and services consumed. One can try to reduce the indirect water footprint by:

- substitution of a consumer product that has a large water footprint by a different type of product that has a smaller water footprint;
- substitution of a consumer product that has a large water footprint by the same product that is derived from another source with smaller water footprint.

Examples of the first sort of substitution are replacing rice consumption in the Netherlands by potatoes or replacing cane sugar by beet sugar. An example of the second sort of substitution is replacing cotton clothes that originate from semi-arid regions with irrigated cotton fields by cotton clothes produced in wetter areas with rain-fed cotton growing. Both sorts of action require that the consumer is provided with proper information about the water footprints of specific products. For the first sort of substitution some general knowledge about the water footprints of different types of products may be sufficient, but for the second sort of substitution individual items need to be labelled in the shop.

Consumers may be able to offset the negative impacts of their *direct* water footprint when local non-profit organisations sell offset-certificates with the aim to invest in improved water resources management. The offset price can be made a function of the annual water volume used. For consumers it will generally be difficult to offset the negative impacts of their *indirect* water footprint, because the variety of goods and services consumed is very large, so that it is impossible to review the various negative impacts and compensate for all. It would be more convenient if the consumer would be offered the choice to buy 'water-neutral' products or buy in water-neutral certified shops. This gives a guarantee that necessary offset efforts have been made already. In a few particular cases, consumers can decide to offset the impacts of their full water footprint in the form of a lump-sum payment. For example, as promoted by the Water Neutral Foundation in Johannesburg, rich travellers who visit a water-scarce country where many people do not even have basic water supply facilities can 'neutralise' their water footprint during their stay in that country by contributing money to projects to enhance sustainable and equitable water use.

3.4 Water neutrality of a business

For many companies, fresh water is a basic ingredient for their operations, while effluents may lead to pollution of the local water system. Initially, public pressure has been the most important reason for sustainability initiatives in businesses. Today, however, many companies recognize that failure to manage the issue of fresh water raises different sorts of business risk, including damage to the corporate image, threat of increased regulatory control, financial risks caused by pollution, and insufficient freshwater availability for operations. A number of multinationals recognise now that proactive management can avoid risks and contribute to their profitability and competitiveness. Business water footprint accounting is increasingly regarded as an essential part of sustainable corporate performance accounting. An increasing number of businesses recognize that not only their operations, but also their supplies depend and impact on natural water systems. The concept of water neutrality is a possible means for a business to reduce and offset the negative impacts of its water footprint.

When can a business be declared 'water neutral'? In line with the general argument made earlier, a first requirement is that all what is 'reasonably possible' has been done to reduce the total water footprint of the business. This is most urgent in regions where the impact of the water footprint is high. A second requirement is that 'reasonable and effective investments' are in place to offset the residual water footprint. The larger the impacts of the residual water footprint, the larger the required investment.

A business can take full responsibility for reducing its operational water; it can strive towards using the best available technology. Besides, a business has influencing power over its suppliers, which it can use to get them to reduce their operational footprint (the business‘s supply-chain water footprint). A business can also switch to another supplier that has a smaller water footprint. Additionally, a business can control or influence the process of designing products such that they inherently use or pollute less water over their complete life cycle. An example: why produce water-use-intensive dishwashers if a similar or even higher quality dishwasher can be made that uses less water per dish wash? Businesses that aim to be water-neutral should take responsibility for improving the water-use characteristics of their products when technology allows.

After maximum efforts have been made to reduce the two components of the business footprint, then offsets are needed to balance the residual water footprint. Because the water footprints of the businesses in one supply chain partially overlap (the supply-chain water footprint of a business in a latter stage of the chain overlaps with the operational water footprints of its direct and indirect suppliers), businesses in one production and supply chain can best cooperate in offsetting the impacts along the supply-chain. The biggest players in the chain – often large food industries or retailers – can take the lead in this.

The ability of businesses to reduce and offset their supply-chain water footprint is limited in the sense that they have to influence others, while they have full control over their operational water footprint. This does not mean however that the supply chain is not their business. A company relying on a supply chain that cannot be characterised as ‘water neutral’ is not water neutral itself. Even when a company has done its utmost best to influence agents in the supply chain to reduce their water use, it does not mean that it was actually successful. If the company still gets inputs from a wasteful supply chain – even though the company is not the one to blame because it did make an effort to change it – the products from this company cannot be called ‘water neutral’ and as a consequence the company itself cannot be called ‘water neutral’.

4. Water neutral: a critical discussion

Water neutral is a strong concept in the sense that it attracts broad interest and invites for positive action. The water-neutral concept offers a great opportunity to translate water footprint impacts into action to mitigate those impacts within both communities and business. The weakness of the concept, however, is that it can easily be adopted to be used in a multitude of different meanings (ENDS, 2007), so that in the end it becomes an empty, meaningless concept and loses its potential to effectively bring about positive change. The greatest threat is therefore that major players in the global community do not manage to arrive at consensus on the precise definition of the concept, creating room for dilution of the concept, which reduces its potential to promote positive action.

There are a number of reasons why – in the current state of development – the water-neutral concept may still lose its potential and turn out to become a weak, more or less meaningless concept. First of all, the term ‘water neutral’ in itself may be misleading and therefore lead to confusion. It is often possible to reduce a water footprint, but it is generally impossible to bring it down to zero. Water pollution can be largely prevented and much of the water used in various processes can be reused. However, some processes like growing crops and washing inherently need water. After having done everything that was technically possible and economically feasible, individuals, communities and businesses will always have a residual water footprint. In that sense, they can never become water neutral. The idea of ‘water neutral’ is different here from ‘carbon neutral’, because it is (at least theoretically) possible to generate enough energy without net emission of carbon, but it will never be possible to live and eat without any water use. Alternative names to ‘water neutral’ that have been suggested include water offset, water stewardship, water use reduction and reuse and pollution prevention and control. However none of these other terms seems to have the same gravity or resonance or leads to the same sort of inspiration within media and the business and NGO communities as the term neutrality. For pragmatic reasons it may therefore be attractive to use the term ‘water neutral’, but there is a definite need to be clear about what it precisely entails if reduction of water use to zero is not possible. It should be clear that the term does not refer to nullifying the water footprint, but to nullifying the negative impacts that can be associated with a water footprint.

A second reason that puts the strong potential of the water-neutral concept at risk is the fact that the concept includes a normative aspect. Consensus needs to be reached about what effort to reduce an existing water footprint can reasonably be expected and what effort (investment) is required to sufficiently offset the residual water footprint. Questions that are still open but that need to be answered clearly as a precondition for the success of the water-neutral concept are:

1. How much reduction of a water footprint can be reasonably expected? The standard may be to implement so-called ‘better management practices’ in agriculture and ‘best available technologies’ in manufacturing, but what are these practices and technologies and how can they be measured? How does one deal with totally new products or activities?

2. What is an appropriate water-offset price? What type of efforts count as an offset? Whether projects or payments, efforts should ideally be focused on those specific areas where a water footprint has greatest impact, but how does the required effort precisely relate to the size of the impact and how does one measure impact and effort?
3. Over what time span should mitigation activities be spread and how long should they last? If the footprint is measured at one period of time, when should the offset become effective?
4. What are the spatial constraints? When a water footprint has impacts in one place, should the offset activity take place in the same place or may it take place within a certain reasonable distance from there?

Third, confusion about the meaning of water neutrality may arise from the question whether one should count the *effort* to reduce and offset or the *effectiveness* of the effort. The term water neutrality suggests that there is a sort of clear positive action that effectively nullifies all negative impacts related to one's water footprint. But even if it has been clearly defined what is meant by 'reasonable reduction' and a 'proper offset effort', it is not yet clear whether the offset effort (a certain price paid, a certain investment made) will be effective. How does one measure effectiveness? And how can one guarantee that offset efforts are indeed contributing to making the positive change (nullify the impacts) that is suggested? For real water-neutrality it is the effect that should count, not the effort made.

A fourth risk to the water-neutrality concept is that it shifts action too much to offsetting, without addressing the more fundamental issue of why undertaking the water-using activity at all. One may argue that a water-neutral golf course in a water stressed area is a contradiction in terminus. It is true that the focus on reduction and offsetting does not address the more fundamental issue of avoiding the water-using product or activity altogether. Strictly spoken, however, avoiding water-intensive products or activities can be part of the effort of becoming water neutral. The key question is whether the issue of reduction through avoidance should be part of the guidelines on what is a 'reasonable reduction' of a water footprint. The issue can also be illustrated with the example of building a new district, which will result in additional water use that can be compensated by taking water-saving and water-treatment measures in other districts. The problem with this approach is that one could argue that the old districts had to replace their old water supply systems anyhow and that wastewater treatment systems, preferably rather sooner than later, had to be built on the account of the old districts anyway, so that these improvements cannot be counted as a water-neutrality success of the new district. By building the new district in a 'water neutral' way, the water footprint of the town does not increase indeed, but the potential to reduce the water footprint below its current level has been taken away.

Finally, accounting systems need to be developed that prevent accounting gaps on the one hand and double counting on the other. With respect to the risk of gaps in accounting: which products or activities need to be included when assessing water footprints and evaluating water neutrality? Does one only need to consider those products/activities that obviously have a significant water footprint, or should one also include products that have a relatively small water footprint? A focus on those products/activities that contribute most to water consumption and pollution seems logical, but where to draw the border? A business producing a beverage that includes a lot of sugar should certainly analyse the water footprint of its sugar intakes and water-neutrality for this business would entail reducing and offsetting the impacts of the sugar-related water footprint. But should it also address the water footprint and water-neutrality of the paper used in the office? There are other questions with respect to the concern of double counting. A business can offset its supply-chain water footprint while the business in the supply chain offsets its own operational water footprint. How to share offsets? And where offsets are achieved in projects that are joint efforts, how much of any calculated water benefits can an individual entity claim?

Talking about the water neutrality of businesses is the same as talking about the water neutrality of the products produced by those businesses. Similarly, talking about water neutrality of consumers is the same as talking about the water neutrality of the products consumed. Apparently, water neutrality of products is the key challenge in which producers and consumers have a shared responsibility. This is in line with the argument made by Lenzen et al. (2007), who describe the challenge of reducing ecological footprints as a responsibility to be shared by producers and consumers as well. The question how they will share this responsibility in practice is open to public debate. Consumers can take responsibility through their consumption behaviour, but they can also demand for governmental regulation of businesses, which can take the form of water-neutral labelling of products or water-neutral certification of businesses.

5. Conclusion

The strength of the water-neutral concept partly lies in its positive connotation, which may trigger communities and businesses to act where otherwise they might not have done so. The strength of the water-neutral concept also lies in its link to the water-footprint concept. A large amount of individuals and businesses are already aware about the external effects of their direct water use and act in order to reduce this direct water use. When the water-neutral concept was not linked to the water-footprint concept, the efforts of individuals and businesses would likely remain limited to actions to reduce their direct water footprint. Linking the idea of water neutrality to the water footprint implies that action is also directed towards reducing and offsetting the negative impacts of the indirect water footprint. In the case of businesses, a key element of water neutrality is that not only measures are taken with respect to the operational water footprint, but also with respect to the supply-chain water footprint. In the case of individuals or communities, it means that they not only focus on reducing household water use (like installing low-flow shower heads and water-saving toilets) but that they also start looking for products labelled as water-neutral.

Despite the possible pitfalls and yet unanswered questions, it seems that the water-neutral concept offers a useful tool to bring stakeholders in water management together in order to discuss water footprint reduction targets and mechanisms to offset the environmental and social impacts of residual water footprints. However, the concept can become really effective in actually contributing to wise management of the globe's water resources only when clear definitions and guidelines will be developed. There will be a need for scientific rigour in accounting methods and for clear (negotiated) guidelines on the conditions that have to be met before one can speak about water neutrality. Undoubtedly there will be a great market for water-neutrality and water-offsetting, comparable to the market for carbon neutrality and offsetting, but the extent to which this market will become effective in contributing to a more efficient, sustainable and equitable use of the globe's water resources will depend on the rules of the market. Without agreed definitions and guidelines on what is water neutrality, the term is most likely to end up as a catchword for raising funds for charity projects in the water sector. In that context, the term can also fulfil a useful function, but it would be 'water neutrality' in its weakest form. It will become a strong concept only when claims towards water-neutrality can be measured against clear standards.

Acknowledgements

This study was carried out as part of the research programme at the University of Twente. A draft of this paper has been discussed within an informal group of stakeholders that gathered around the topic of ‘water neutrality’ for the first time on 12 September 2007 at WWF-Netherlands, Zeist, and the second time on 22 January 2008 at UNESCO-IHE, Delft, the Netherlands. I like to thank the participants of these meetings for the fruitful discussions that we have had and the useful comments that were made. Thanks to: Pancho Ndebele from the Emvelo Group, Richard Holland, Stuart Orr and Arjan Berkhuysen from WWF, Derk Kuiper from Good Stuff International, Greg Koch and Denise Knight from The Coca Cola Company, Claus Conzelmann from Nestlé, Erik de Ruyter van Steveninck and Assela Pathirana from the UNESCO-IHE Institute for Water Education and Jack Moss from Aquafed, Suez and the World Business Council on Sustainable Development. The responsibility for the contents of this report remains with the author.

References

Allan, J.A. (1998) Virtual water: A strategic resource, global solutions to regional deficits, Groundwater 36(4), 545-546.

Ayres, R.U. and Ayres, L.W. (1998) Accounting for resources, 1: Economy-wide applications of mass-balance principles to materials and waste, Edward Elgar, Cheltenham, UK.

Ayres, R.U. and Ayres, L.W. (1999) Accounting for resources, 2: The life cycle of materials, Edward Elgar, Cheltenham, UK.

BfW (2006) Blueprint for water: 10 steps to sustainable water by 2015, Blueprint for Water, London, UK.

Chapagain, A.K. and Hoekstra, A.Y. (2004) Water footprints of nations, Value of Water Research Report Series No.16, UNESCO-IHE, Delft, the Netherlands.

Chapagain, A.K., Hoekstra, A.Y., Savenije, H.H.G. and Gautam, R. (2006) The water footprint of cotton consumption: An assessment of the impact of worldwide consumption of cotton products on the water resources in the cotton producing countries, *Ecological Economics* 60(1): 186-203.

Chapagain, A.K. and Hoekstra, A.Y. (2007) Water neutral calculator, University of Twente, Enschede, the Netherlands.

De Fraiture, C., Cai, X., Amarasinghe, U., Rosegrant, M. and Molden, D. (2004) Does international cereal trade save water? The impact of virtual water trade on global water use, Comprehensive Assessment Research Report 4, IWMI, Colombo.

Discover Magazine (2008) Everything you know about water conservation is wrong: Forget short showers, worry about the 6,340 gallons of "virtual water" in your leather bag, Discover Magazine, May 28th, 2008.

EA (2007) Towards water neutrality in the Thames Gateway, Summary report, Environmental Agency, Bristol, UK.

ENDS (2007) Confusion as companies and government talk of 'water neutrality', ENDS Report 389, pp. 6-7, Environmental Data Services, London, UK.

FAO (2008) CropWat, Food and Agriculture Organization, Rome, www.fao.org/nr/water/infores_databases_cropwat.html

Gerbens-Leenes, P.W. and Hoekstra, A.Y. (2008) Business water footprint accounting: A tool to assess how production of goods and services impacts on freshwater resources worldwide, Value of Water Research Report Series No.27, UNESCO-IHE, Delft, the Netherlands.

Gleick, P.H. (ed.) (1993) Water in crisis: A guide to the world's fresh water resources, Oxford University Press, Oxford, UK.

Hails, C., Loh, J. and Goldfinger, S. (2006) Living planet report 2006, WWF, Gland, Switzerland.

Hoekstra, A.Y. (ed.) (2003) Virtual water trade: Proceedings of the International Expert Meeting on Virtual Water Trade, Delft, The Netherlands, 12-13 December 2002, Value of Water Research Report Series No.12, UNESCO-IHE, Delft, the Netherlands.

Hoekstra, A.Y. (2006) The global dimension of water governance: Nine reasons for global arrangements in order to cope with local water problems, Value of Water Research Report Series No.20, UNESCO-IHE, Delft, the Netherlands.

Hoekstra, A.Y. (2007) Human appropriation of natural capital: Comparing ecological footprint and water footprint analysis, Value of Water Research Report Series No.23, UNESCO-IHE, Delft, the Netherlands.

Hoekstra, A.Y. and Chapagain, A.K. (2007) Water footprints of nations: water use by people as a function of their consumption pattern, *Water Resources Management* 21(1): 35-48.

Hoekstra, A.Y. and Chapagain, A.K. (2008) Globalization of water: Sharing the planet's freshwater resources, Blackwell Publishing, Oxford, UK.

Hoekstra, A.Y. and Hung, P.Q. (2002) Virtual water trade: a quantification of virtual water flows between nations in relation to international crop trade, Value of Water Research Report Series No.11, UNESCO-IHE, Delft, the Netherlands.

JPMorgan (2008) Watching water: A guide to evaluating corporate risks in a thirsty world, New York, USA.

Kampman, D.A., Hoekstra, A.Y. and Krol, M.S. (2008) The water footprint of India, Value of Water Research Report Series No.32, UNESCO-IHE, Delft, the Netherlands.

Lenzen, M., Murray, J., Sack, F. and Wiedmann, T. (2007) Shared producer and consumer responsibility: Theory and practice, Ecological Economics 61(1): 27-42.

Oki, T. and S. Kanae, (2004) Virtual water trade and world water resources, Water Science and Technology 49(7): 203-209.

Postel, S.L., Daily, G.C., and Ehrlich, P.R. (1996) Human appropriation of renewable fresh water, *Science* 271: 785-788.

Rees, W.E. and Wackernagel, M. (1994) Ecological footprints and appropriated carrying capacity: Measuring the natural capital requirements of the human economy, In: Jansson, A.M., Hammer, M., Folke, and Costanza, R. (eds.) Investing in natural capital: The ecological economics approach to sustainability, Island Press, Washington, D.C., pp. 362-390.

Smakhtin, V., Revenga, C., and Döll, P. (2004) Taking into account environmental water requirements in global-scale water resources assessments Comprehensive Assessment Research Report 2, IWMI, Colombo, Sri Lanka.

TCPA (2008) Sustainable water management: eco-towns water cycle worksheet, Town and Country Planning Association, London, UK.

The Economist (2008) Footprints in carbon, nitrogen and water, The Economist, May 19th, 2008.

The Independent (2008) Forget carbon: you should be checking your water footprint, The Independent, April 21st, 2008.

UNESCO (2006) Water, a shared responsibility: The United Nations world water development report 2, UNESCO Publishing, Paris, France / Berghahn Books, Oxford, UK.

Van Oel, P.R., Mekonnen M.M. and Hoekstra, A.Y. (2008) The external water footprint of the Netherlands: Quantification and impact assessment, Value of Water Research Report Series No.33, UNESCO-IHE, Delft, the Netherlands.

Verkerk, M.P., Hoekstra, A.Y. and Gerbens-Leenes, P.W. (2008) Global water governance: Conceptual design of global institutional arrangements, Value of Water Research Report Series No.26, UNESCO-IHE, Delft, the Netherlands.

Water Neutral (2002) Get water neutral! [brochure distributed among delegates at the 2002 World Summit on Sustainable Development in Johannesburg], The Water Neutral Foundation, Johannesburg, South Africa.

WBCSD (2006) Business in the world of water: WBCSD scenarios to 2025, World Business Council for Sustainable Development, Conches-Geneva, Switzerland.

WWF (2008) De waterfootprint van Nederland (in Dutch), Wereld Natuur Fonds, Zeist, the Netherlands.

Zygmunt, J. (2007) Hidden waters, Waterwise, London, UK.

Glossary

Water consumption – the volume of water used that gets 'lost' through evaporation. It includes the evaporation from artificial surface water reservoirs and from channels that lead the water from the place where it is withdrawn to the place where it will be used.

Water footprint – an indicator of water use that looks at both direct and indirect water use. Water use is measured in terms of water volumes consumed (evaporated) and/or polluted. The water footprint includes three components: the **blue, green and grey water footprint**. The blue water footprint refers to the volume of 'blue water' (surface or ground water) that has been evaporated as a result of its appropriation for human purposes. The green water footprint refers to the volume of 'green water' (rainwater stored in the soil) that has been evaporated as a result of its appropriation for human purposes. The grey water footprint is the volume of polluted water that associates with the production of goods and services. The latter is estimated 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. A water footprint can be calculated for any well-defined group of consumers (e.g. an individual or family or the inhabitants of a village, city, province, state or nation) or producers (e.g. a public organization, private enterprise or whole economic sector). The water footprint is a geographically and temporally explicit indicator, not only showing volumes of water consumption and pollution, but also the locations and timing.

Water footprint of a product – The water footprint of a product (good or service) is the total volume of fresh water used to produce the product, summed over the various steps of the production chain. The water footprint of a product is the same as its 'virtual water content', but is more than a number alone. The water footprint of a product shows not only the total volume of water use (the virtual water content), but also where and when the water is used.

Water footprint of a consumer – the sum of its direct water use, i.e. the water use at home or in the garden, and its indirect water use, i.e. the water use in the production and supply chains of the goods and services consumed. The indirect water use can be found by multiplying all products consumed by their respective product water footprint.

Water footprint of a business - the total volume of fresh water that is used directly and indirectly to run and support a business. The water footprint of a business consists of two components: the direct water use by the producer, for producing/manufacturing and supporting activities, and the indirect water use, i.e. the water use in the producer's supply chain. The 'water footprint of a business' is the same as the total 'water footprint of the business output products'.

Water neutral – A good, service, individual consumer, community or business is water neutral when the negative externalities of the water footprint of the good, service, individual consumer, community or business have been reduced and offset. To be 'water neutral' there are two conditions: first, all what is 'reasonably possible' should have been done to reduce the existing water footprint; and second, the impacts of the residual water footprint are offset by making a 'reasonable investment' in establishing or supporting projects that aim at the sustainable and equitable use of water.

Water offset – Offsetting the negative impacts of a water footprint is a part of water neutrality.

Water pollution – reduced water quality due to human activities. In order to compare the volume of fresh water lost from the local system through evaporation with the volume of fresh water lost through pollution, the latter can be translated into a 'polluted water volume' by calculating 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.

Water use – a general term that refers to freshwater use for human purposes. In many texts the term 'water use' refers to 'water withdrawal', the classic indicator of water use. In this report, the term 'water use' refers to the sum of total water consumption and water pollution (Figure 2.3). The term 'direct water use' of a consumer or producer refers to the water use by the consumer or producer itself. The term 'indirect water use' refers to the water use behind the products consumed by the consumer or used as inputs by the producer.

Water withdrawal – the volume of fresh water that is withdrawn (abstracted) from ground- or surface water in order to serve a human purpose.

Value of Water Research Report Series

Reports are downloadable from www.waterfootprint.org

1. Exploring methods to assess the value of water: A case study on the Zambezi basin
   A.K. Chapagain – February 2000
2. Water value flows: A case study on the Zambezi basin
   A.Y. Hoekstra, H.H.G. Savenije and A.K. Chapagain – March 2000
3. The water value-flow concept
   I.M. Seyam and A.Y. Hoekstra – December 2000
4. The value of irrigation water in Nyanyadzi smallholder irrigation scheme, Zimbabwe
   G.T. Pazvakawambwa and P. van der Zaag – January 2001
5. The economic valuation of water: Principles and methods
   J.I. Agudelo – August 2001
6. The economic valuation of water for agriculture: A simple method applied to the eight Zambezi basin countries
   J.I. Agudelo and A.Y. Hoekstra – August 2001
7. The value of freshwater wetlands in the Zambezi basin
   I.M. Seyam, A.Y. Hoekstra, G.S. Ngabirano and H.H.G. Savenije – August 2001
8. 'Demand management' and 'Water as an economic good': Paradigms with pitfalls
   H.H.G. Savenije and P. van der Zaag – October 2001
9. Why water is not an ordinary economic good
   H.H.G. Savenije – October 2001
10. Calculation methods to assess the value of upstream water flows and storage as a function of downstream benefits
    I.M. Seyam, A.Y. Hoekstra and H.H.G. Savenije – October 2001
11. Virtual water trade: A quantification of virtual water flows between nations in relation to international crop trade
    A.Y. Hoekstra and P.Q. Hung – September 2002
12. Virtual water trade: Proceedings of the international expert meeting on virtual water trade
    A.Y. Hoekstra (ed.) – February 2003
13. Virtual water flows between nations in relation to trade in livestock and livestock products
    A.K. Chapagain and A.Y. Hoekstra – July 2003
14. The water needed to have the Dutch drink coffee
    A.K. Chapagain and A.Y. Hoekstra – August 2003
15. The water needed to have the Dutch drink tea
    A.K. Chapagain and A.Y. Hoekstra – August 2003

16. Water footprints of nations
    Volume 1: Main Report, Volume 2: Appendices
    A.K. Chapagain and A.Y. Hoekstra – November 2004
17. Saving water through global trade
    A.K. Chapagain, A.Y. Hoekstra and H.H.G. Savenije – September 2005
18. The water footprint of cotton consumption
    A.K. Chapagain, A.Y. Hoekstra, H.H.G. Savenije and R. Gautam – September 2005
19. Water as an economic good: the value of pricing and the failure of markets
    P. van der Zaag and H.H.G. Savenije – July 2006
20. The global dimension of water governance: Nine reasons for global arrangements in order to cope with local water problems
    A.Y. Hoekstra – July 2006
21. The water footprints of Morocco and the Netherlands
    A.Y. Hoekstra and A.K. Chapagain – July 2006
22. Water's vulnerable value in Africa
    P. van der Zaag – July 2006
23. Human appropriation of natural capital: Comparing ecological footprint and water footprint analysis
    A.Y. Hoekstra – July 2007
24. A river basin as a common-pool resource: A case study for the Jaguaribe basin in Brazil
    P.R. van Oel, M.S. Krol and A.Y. Hoekstra – July 2007
25. Strategic importance of green water in international crop trade
    M.M. Aldaya, A.Y. Hoekstra and J.A. Allan – March 2008
26. Global water governance: Conceptual design of global institutional arrangements
    M.P. Verkerk, A.Y. Hoekstra and P.W. Gerbens-Leenes – March 2008
27. Business water footprint accounting: A tool to assess how production of goods and services impacts on freshwater resources worldwide
    P.W. Gerbens-Leenes and A.Y. Hoekstra – March 2008
28. Water neutral: reducing and offsetting the impacts of water footprints
    A.Y. Hoekstra – March 2008
29. Water footprint of bio-energy and other primary energy carriers
    P.W. Gerbens-Leenes, A.Y. Hoekstra and Th.H. van der Meer – March 2008
30. Food consumption patterns and their effect on water requirement in China
    J. Liu and H.H.G. Savenije – March 2008
31. Going against the flow: A critical analysis of virtual water trade in the context of India's National River Linking Programme
    S. Verma, D.A. Kampman, P. van der Zaag and A.Y. Hoekstra – March 2008
32. The water footprint of India
    D.A. Kampman, A.Y. Hoekstra and M.S. Krol – May 2008
33. The external water footprint of the Netherlands: Quantification and impact assessment
    P.R. van Oel, M.M. Mekonnen and A.Y. Hoekstra – May 2008