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Water footprint overview in the governmental, public policy, and corporate contexts

Water footprints have evolved from the quantification of virtual water theory and have been linked to advocacy, awareness, measurement for baselines and, now, to water management decision-making. To date, the role of water footprints in water policy has been limited to a few examples in the government and the corporate contexts. In this article, we show how both the government in China and one particular brewery company (SABMiller) have used the water footprint concept. In China, a sharp increase in the per capita water footprint has been reported, mainly due to diet shifts in recent decades. Partly in response to this change, the Chinese government has promoted the strategy of a “water-saving society development” to enhance water use efficiency and reduce the national water footprint. Similarly, SABMiller have used the water footprint method to estimate water reliance in their supply chain and overlay this information with business risks in the value chain. We conclude that the evolvement of the water footprint concept from basic quantitative studies to a powerful advocacy tool can help support policy development, decision-making and business risk awareness for efficient water use.

Keywords: water footprint, policy, China, SABMiller

Introduction

Development of the water footprint concept

The water footprint concept was first introduced in 2002 by Arjen Hoekstra at the International Expert Meeting on Virtual Water Trade, held in Delft, The Netherlands (Hoekstra, 2003). The concept builds on work by Allan (1993) related to the virtual water trade. The

water footprint takes the theory of virtual water trade and quantifies the amounts of water used in various processes. This defines the water footprint of an individual, community or business as the total volume of freshwater used to produce the goods and services consumed by the individual or community or produced by the business (Hoekstra and Chapagain, 2008). Prior to the quantification of virtual water, the relationship between water and food was mainly studied from the supply side. This concept has led to a focus on the studies on water–food relations by considering food consumption patterns, and by linking this consumption to production sites.

The water footprint concept generated interest soon after it was introduced, mainly because it was understandable as an advocacy tool and was an easily communicated message to stakeholders. The concept has been discussed at water-related conferences, such as the 3rd World Water Forum in Japan in 2003, the expert meeting on “virtual water trade” in Bonn in 2005, the 4th World Water Forum in Mexico City in 2006 and at the World Water Weeks in Stockholm in Sweden in 2008 and 2009. In October of 2008, the Water Footprint Network (WFN) was formally established in Enschede, The Netherlands, and aims to accelerate the research, applications and discussions on water footprints. In particular, the business community has frequent conferences and meetings on water footprints, such as the Corporate Water Footprinting Conferences in 2008/2009 in San Francisco, London, Brussels and Miami, as well as sessions at the 5th World Water Forum in Istanbul.

This paper looks into both public and private sector uses and advancements of the water footprint concept, with an example from China and one from the global brewery firm, SABMiller.

Review of water footprint research

A water footprint can be assessed for a well-defined region or product. At the global scale, Hoekstra and Chapagain (2007) quantified the water footprints of nations as a first attempt at quantifying the volume of water needed for the production of the goods and services consumed by humanity. At the national level, water footprints have been assessed for China (Liu and Savenije, 2008; Liu et al., 2008), India (Kampman et al., 2008), Spain (Aldaya et al., 2008) and the UK (Chapagain and Orr, 2008). Although most efforts have concentrated on the water footprint assessment of countries, spatial and temporal analyses of the water footprint below the national level have also been published (Chapagain and Orr, 2008; Aldaya and Llamas, 2009) to illustrate the refinement of the numbers at regional and even catchment levels.

A water footprint can also be calculated for a specific activity, good or service. For example, Chapagain et al. (2006) elaborated the water footprint of cotton; Chapagain and Hoekstra (2007) assessed the water footprint of coffee and tea; Gerbens-Leenes et al. (2009) and Yang et al. (2009) estimated the water footprint of primary energy carriers, while Jongschaap et al. (2009) discussed the water footprint of bio-energy from the crop *Jatropha*. The water footprint concept has also been used to assess water use in businesses and other organisations (WBCSD, 2006; Gerbens-Leenes and Hoekstra, 2008). A detailed overview of this water footprint-related research has been described by Hoekstra (2009).

A review of water footprint applications in formulating policies

During the last part of the 1990s there was some effort to include virtual water considerations in policy frameworks. However, this met with strong resistance from water managers and economists who did not value the maturity of this concept in water policy formulation. But, while official policy may have omitted conscious decision-making on water comparative advantages, this was already the practice of a number of countries, whether explicitly stated or not. As Allan (1999) has shown from the Middle East and North Africa (MENA) region, those countries with poor water endowments were indeed huge importers of water intensive foodstuffs. Published works on water quality, and particularly the virtual water trade implications, have also been explored (Dabrowski et al., 2009) for the context of South Africa; this has direct links to grey water accounting in water footprints.

As water footprints evolved, there have been links to water management decision-making, yet to date the role of water footprint methods in water policy is limited to a few river basins. Work in Spain around the Guadiana basin (Aldaya and Llamas, 2009) has resulted in an economic assessment of water footprints that have now been captured as part of the Water Framework Directive assessments in that country. The interest and relevance of virtual water trading for future food security concerns, and the introduction of water footprint assessments of economic activities in basins, may lead to explicit policy making at national levels with regard to the use of water resources especially for higher value uses.

In the business world, the water footprint concept has helped to shed light on business water-related risk. It is perhaps through this

lens that the water footprint is beginning to influence business strategies, which, in turn, may come to bear in formulating water policy that is coherent and consistent for business sectors.

Water footprint overview in the governmental context

Water footprint in China – a historical overview

The per capita water footprint is calculated by multiplying the food consumption per food item by the virtual water content (VWC) of the corresponding food item and then summing the results for the food categories. The VWC indicates the amount of water used to produce a unit food item (Liu et al., 2007). In this section, two major categories are used – animal products and vegetal products. Animal products include eight food items – beef, pork, poultry, mutton and goat meat, fish and seafood, eggs, milk and animal fats. Vegetal products include 10 food items – four cereals (rice, wheat, maize and other cereals), starchy roots, sugar and sweeteners, soybeans and other oil crops, vegetable oils, vegetables and fruits. The VWC of each food item is obtained from Liu and Savenije (2008), while food consumption patterns in each year are obtained from the FAO (2006). We assume VWC values remain the same for the same food item in different years, as the values of the VWC are not available for all years. Although the VWC fluctuates with different levels of technology, our assumption should not influence the analysis presented in this study, as its main objective is to demonstrate the effect of consumption patterns alone on a per capita water footprint, while holding all other variables constant.

The per capita water footprint in China has increased significantly

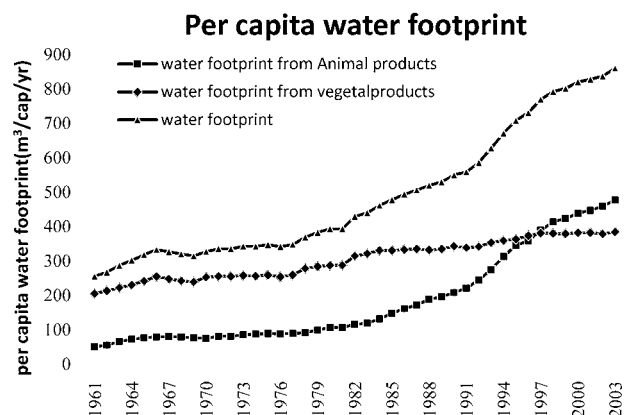


Figure 1. Per capita water footprint from 1961 to 2003 in China.

from below 300 m³/cap/yr in the early 1960s to 868 m³/cap/yr today (Figure 1). The changes are closely related to the shifts in food consumption patterns, which are associated with economic growth, increasing living standards and adjustments of agricultural policies in China. In 1961, the last year of the so-called “three bad years”, contained a series of calamities resulting directly in the deaths of tens of millions from starvation. This period was characterised by very low food consumption due to food shortages. The average total cereal consumption was around 120 kg/cap/yr while the consumption of ani-



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mal products was only 12 kg/cap/yr. People relied heavily on starchy roots to meet their basic caloric energy intake. The consumption of starchy roots was 112 kg/cap/yr, almost the same as the consumption of cereals. Given the low food consumption level and the dominance of vegetal product consumption, the water footprint was very low. In 1961, the Chinese government started to introduce a series of new economic policies to boost agricultural production. These policies took effect and resulted in rising food consumption, particularly for wheat and rice. However, these policies only lasted for a few years before the Cultural Revolution occurred (between 1966 and 1976). The Cultural Revolution involved devastating social turmoil and adverse effects on agricultural production. Over this period, food consumption barely changed, leading to stagnation of the water footprint.

After the Cultural Revolution, China abandoned collective agriculture and, in 1978, assigned most agricultural land to families under the household responsibility system. The adoption of this system stimulated the farmers' enthusiasm for food production, largely enhancing the domestic food supply and consequently helping increase the level of food consumption. Between 1978 and 1984, the steady rise in the per capita water footprint was largely a result of the higher consumption of cereals, starchy roots and animal products. After 1984, the consumption of cereals and starchy roots started to decline slightly, while the consumption of animal products, vegetal oils, and vegetables and fruits continued to increase, leading to continuous growth of the per capita water footprint.

Since the 1990s, the consumption of animal products has grown markedly from 49 kg/cap/yr in the 1990s to 116 kg/cap/yr in 2003. The consumption of vegetables and fruits more than doubled from 116 kg/cap/yr to 320 kg/cap/yr, while the consumption of cereals and starchy roots declined slightly. The VWC of animal products is much higher than that of vegetal products. For example, the VWC of beef is around 13 m³/kg; much larger than that of wheat at around 1 m³/kg.

The rise in the consumption of animal products was the very reason for the increase in the per capita water footprint in the 1990s and into the new Millennium.

Diet shifts have led to obvious changes in the proportion of the water footprint from animal products, accounting for over half of the water footprint since 1997 (Figure 1). In the 1960s and 1970s, the water footprint from animal products was very small compared with that from vegetal products (Figure 1). This is a reflection of the low living standards of the Chinese in these periods. Since the 1980s, with economic growth increasing and urbanisation spreading, the consumption of animal products has gradually increased, leading to the growth in the water footprint from animal products. In contrast, the water footprint from vegetal products has barely changed. As a result of these diet shifts, the water footprint from animal products has exceeded that of vegetal products from 1997 on. In 2003, it accounted for 55% of the total water footprint.

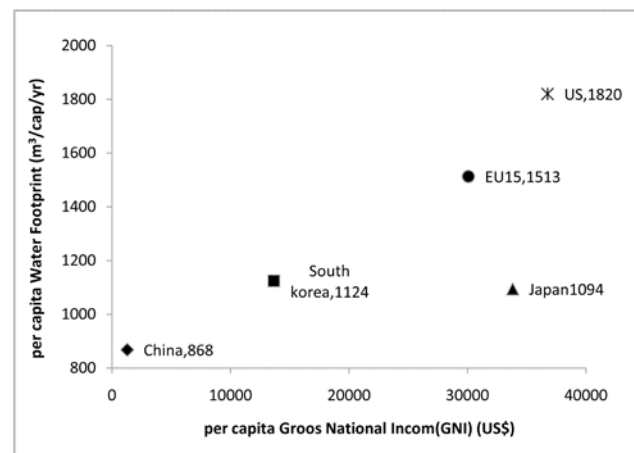


Figure 2. Per capita water footprint vs. gross national income (GNI).

national income (GNI) in a country. In general, a higher level of per capita GNI corresponds to a higher level of per capita water footprint (Figure 2). The USA and the EU15 (the 15 member countries of the EU prior to the accession of candidate countries on 1 May 2004) have a much higher level of per capita GNI. As can be seen, they both have a much higher level of per capita water footprint. Two Asian countries, Japan and South Korea, also have higher levels of both per capita GNI and water footprint. China's water footprint is still well below that of many developed countries and is indeed less than half the water footprint of the United States. It is likely that the per capita water footprint of China will further increase in the future as the economic situation continues to change. A larger water footprint will further pose greater pressure on the looming water scarcity crisis in China, particularly in the northern part of China where water scarcity is the most serious, and agricultural production is high.

Spatial distribution of the water footprint in China

The northern part of China has a generally higher per capita water footprint than in the south (Figure 3). This is explained in part by the higher meat consumption in the north. Low precipitation together with low temperatures leads to harsh conditions for crop production in several provinces in the north, e.g. Inner Mongolia and Qinghai province. Instead, farmers raise a large number of animals on extensive pasture areas. Traditionally, residents relied heavily on animal products for their daily food consumption, leading to a high per capita water footprint. It is no wonder that Inner Mongolia and Qinghai province are the two provinces with the highest per capita water footprint. Besides the dietary pattern, the dry weather and high potential evapo-transpiration may also contribute to the higher water footprint in the north. There is also a trend for the eastern provinces to have a relatively higher per capita water footprint than the western provinces. This may be caused by the different levels in the standard of living. The per capita income is much higher for those in the coastal areas than those in the western regions. Guangxi province turns out to be the province with the lowest per capita water footprint.

The water footprint intensity, defined as the ratio of the per capita water footprint to the per capita GDP, has a very clear trend: a low

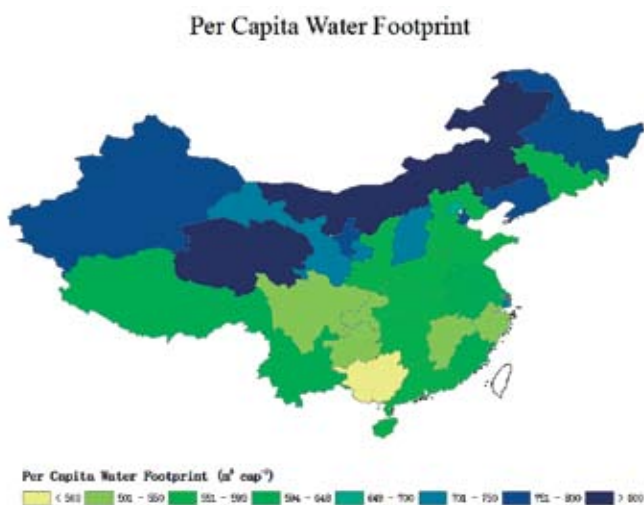


Figure 3. Spatial distribution of the water footprint in China

Water Footprint Intensity

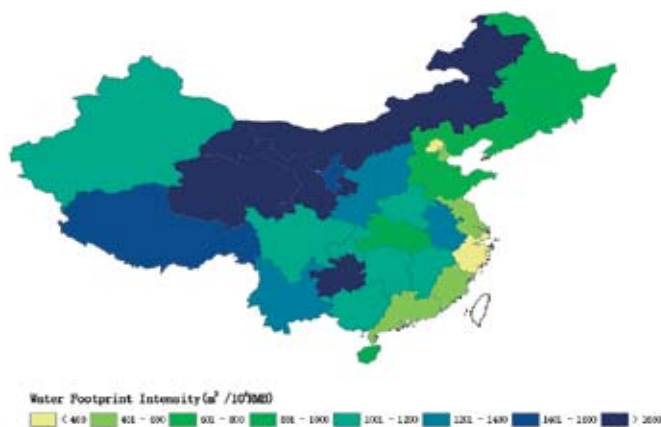


Figure 4. Spatial distribution of the water footprint intensity in China

water footprint intensity in the eastern provinces and a high water footprint intensity in the western provinces. This trend is a result of a higher standard of living in the east and a lower standard of living in the west. This is also a reflection of rich regions that have the capacity to develop more water-saving methods to conserve water resources.

Long et al. (2006) studied the factors influencing the total water footprints in provinces in China. They concluded that (1) population is the major driving force influencing the magnitude of the total water footprint; (2) richness (in terms of per capita GDP) has a significant positive influence on the water footprint; and (3) climatic conditions (in terms of potential evaporation) also have significant influences on the water footprint. From these conclusions, we can see that the water footprint of China will further increase in the next 20 years with population growth and economic development. The impacts of climate change on water footprints are not yet clear. However, climate change is expected to play a less important role in influencing China's water footprint than the population and dietary change associated with continued economic development.

Government perspective on water footprints: water-saving society development

The continuous growth of the water footprint has imposed a higher pressure on scarce water resources in China. Water scarcity has become a serious constraint for future economic and societal development. The Chinese government has realised the seriousness of this problem and in response has promoted the strategy of a "water-saving society development".

The Chinese government started to promote the idea of a "water-saving society" in 2000. The essence of this is to establish a water resources management system on the basis of water rights and water market theory. The government provides guidance to society and formulates policies for the market. The objectives are (1) to increase water use efficiency, (2) to reduce the per capita water footprint and water footprint intensity as much as possible and (3) to promote "harmonious development" of the economy, resources and the environment.

In 2002, a revised water law came into effect. The Water Law of the People's Republic of China was adopted at the 24th meeting of the Standing Committee of the Sixth National People's Congress on 21

January 1988. It was revised at the 29th meeting of the Standing Committee on 29 August 2002. In Article 8 of this revised law, it is clearly stated that “the state shall strictly carry out water saving and devote major efforts to implementing water-saving measures, popularise new water-saving technologies and processes and develop water-saving industries, agriculture and services, and establish a water-saving society”. For the first time, the formulation of a water-saving society was written into China’s water law.

In 2005, a policy document entitled the “China Water Conservation Technology Policy Outline” was published. This document provides guidance for the development and application of water conservation technologies. It also gives targets for this development between 2005 and 2010. For example, industrial water use will remain in “micro-growth”, agricultural water use will remain at “zero-growth” and water footprint intensity in cities will have to show a gradual reduction.

In 2007, the 11th Five-year Plan for a Water-saving Society Establishment was published. This document makes clear the targets and tasks of water-saving society development. According to this document, from 2005 to 2010, the blue water footprint intensity should be reduced by 20%, irrigation water efficiency should be improved from 0.45 to 0.5, and the blue water footprint per added value in industry should be reduced by 30%. The seepage rate in urban water supply pipelines should not exceed 15% by 2010.

Water footprint overview in the corporate contexts

In alignment with government awareness of water issues, there has also been a radical increase in media, public and business recognition of the importance of water from social, economic and ecological perspectives. This is due in part to a greater understanding of the pressures and risks associated with the world’s freshwater resources. As a result, more progressive governments have begun to reform water policies and reassess their water-related priorities, and multinational companies have begun to assess the risks and uncertainties they face throughout their operations and supply chains (UN, 2009).

For companies, the multiple drivers that influence water availability and use interact with each other in ways that are often not well understood, predicted or managed. A major obstacle is properly evaluating water availability and reliance. Response from the private sector hinges on poorly coordinated methods for estimating water use and impacts at an operational level, and in the miscalculation of embedded water in supply chains. There also remains a large uncertainty and misunderstanding concerning interactions and the sometimes counter-balancing effects of water uses and responses to shortages.

The formulation of the Water Footprint Network (WFN) in 2009 was to address some of these issues and link with the recent uptake in business interests in water. While the CEO Water Mandate and World Economic Forum (WEF) processes provide frameworks and platforms for business discussions on water issues, the need for measurements of water use and impacts has been made clear. There is also now a large push for water disclosure following on from the success of the carbon disclosure project and Global Reporting Initiative (GRI), as well as investor and insurance concerns over capital outlays exposed to water risk issues.

SABMiller: a water footprint case study

A water footprint is only useful for companies when it informs better decision-making. In the context of a business, this means enabling the business to make better decisions regarding how it manages its plants, how it works with suppliers, or how it engages with governments on policy issues. In 2008 and 2009, SABMiller and the World Wide Fund for Nature (WWF) collaborated on research and a subsequent report to use the water footprint analysis for the company. The report discusses results in South Africa and the Czech Republic and what they mean for SABMiller’s business and action plans in response to the findings. The objective was to look beyond the basic water footprint numbers into the context of SABMiller’s water use, in particular by considering water use for different agricultural crops in specific water catchments.

Water-related business risks emanate from changes to the resource in terms of quality or quantity. Risks then manifest themselves in reputational impacts, costs, regulatory changes and, ultimately, the bottom line. Water is not only used at the primary manufacturing site, but, rather, touches the entire value chain with varying degrees of in-



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tensity. Now, more than ever, there is a convincing case to be made for a comprehensive approach to water management that not only looks at internal processes, but also considers the supply chains that companies source from and the communities and ecosystems these activities interact with. Being aware of, and understanding, the water challenges they face undoubtedly allows businesses to make better management decisions and provides the platform to engage with a broader set of stakeholders to address issues outside their direct sphere of influence.

SABMiller has acknowledged these risks and has made water one of the company's top sustainable development priorities. They promote responsible water use throughout their operations, and encourage their suppliers to do the same. They have invested significant management time at the local and global levels in understanding the challenges of water scarcity and quality, and what these may mean for their business (SABMiller, 2009).

The water footprint study considered the results in the context of ecological risks and needs, business risks and needs and the broader water policy context. The footprints were used to develop a matrix of water risk for each business covering blue water, green water and grey water, and, in response, to develop local action plans to mitigate these risks. It is no surprise that agricultural water use was highlighted as the biggest risk area in the South African water footprint.

In the Czech Republic, SABMiller is considering projects to initiate in order to understand the risk of climate change on water availability and how this may impact crop growth in the future. In addition, it is reviewing how legislative risks may impact its crop growing areas, with particular reference to groundwater and nitrate limits, and engaging with suppliers in the process. The aggregate volumes of water provided an overall picture of green and blue water use in the value chain and presented a picture of risk and opportunity costs. The South African water footprint, in particular, highlighted that crop water use within the context of available resources was the most important element. However, even this number needs to be treated with care, because there is no simple answer as to what is an acceptable, fair or efficient use of water for a particular purpose. These questions always need to be answered in the context of local economic, social and environmental needs, government priorities, available technologies and the structure of the agriculture industry. In this sense, the water footprint links the total volumes and opportunity costs of water with regulations, policies, laws, allocations and discharges. In doing so, it has opened up new understanding within the company for long-term strategic planning.

The policy overlay in South Africa was the most telling, and provided a clear example of the benefits of obtaining a clear understanding of the likely risks and opportunities around water use, both at facility level and in the broader value chain. Four key policy issues were identified during the course of the South African study.

Water allocation and resource protection

The South African Water Act is perhaps one of the most progressive of its kind, providing specific allocations to protect the ecological integrity of water bodies and ensuring sufficient availability for domestic consumption before industrial water users are allocated water rights. To manage this process a comprehensive catchment management strategy has been established in the country, which governs licensing, water use efficiency and determination of illegal water use.

Water use efficiency

Of particular relevance in the drive for efficiency is the government's drive for geography-specific water conservation and demand management. The result of this is that there is a high likelihood of licensing and allocations being based on water use efficiency and a more focused look at water reuse and recycling.

Water use licensing and enforcement

This relates to where water rights and licenses are withheld for certain types of activity considered to have a detrimental impact on water resources and the monitoring and enforcement of these directives. An important impact of this is the move towards reducing the amount of water available to agriculture for example, in favour of other water users.

Economic instruments and pricing

Finally, the use of economic instruments to manage water will become more apparent in the future. This will include full cost pricing in relation to water infrastructure development, water charges related to efficiency of use of the resource and reviewing the structure of the polluter pays principle insofar as waste discharges are concerned. These elements of water policy can, potentially, significantly impact the management and use of water resources. By having a fuller understanding of the relevant policy frameworks, local managers are able to make informed investment decisions for the company.

Summary and conclusion

This article provides case studies on the assessment and application of this concept in the government, public policy and corporate contexts. The first case study shows a sharp increase in the per capita water footprint in China in the 1990s and into the new Millennium, largely due to dietary shifts from vegetal to animal products. Trends indicate that the future per capita water footprint will further increase in the next few decades, which will no doubt put high pressure on the limited water resources in China, particularly in the north. In response to this looming water pressure, the Chinese government has advocated the development of a "water saving society" to reduce the per capita water footprint and water footprint intensity. The water policies formulated are expected to help improve water use efficiencies and lead to consistent development of the economy, resources and the environment. However, it also needs to be pointed out that the current policies are mainly "blue" water biased. Future policies should take a more comprehensive approach and take "green" water into account to optimise the water footprint in China.

The business example exemplifies how the measurement and quantification of water in the value chain has brought new insights to a company seeking to understand their risks arising from water use. To what extent a detailed water footprint of a company is required, however, is debatable, as water-related risk is more aligned to regulatory, government and policy coherence where water is used. These issues require less knowledge of individual water uses than they do of the cumulative impacts. However, the basic understanding of water use for benchmarking, raising awareness inside the company and com-

paring with locally relevant information is highly desirable in a water-constrained world. From this perspective, water footprints allow companies to better grasp water issues and their relative contribution to local situations.

The water footprint concept has evolved from basic quantitative studies to a powerful advocacy tool, relevant policy support, business risk awareness and decision-making and now an assessment tool for policy processes. By itself, a water footprint does not solve complicated water management challenges, but it can be applied, as shown here, to support awareness and policy development and contribute to positive actions in watersheds. ■

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