UNESCO-IHE
Institute for Water Education

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November 2013

Wise freshwater allocation:

Water footprint caps by river basin, benchmarks by product and fair water footprint shares by community

Value of Water

Research Report Series No. 63

WISE FRESHWATER ALLOCATION:

WATER FOOTPRINT CAPS BY RIVER BASIN, BENCHMARKS BY PRODUCT AND FAIR WATER FOOTPRINT SHARES BY COMMUNITY

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NOVEMBER 2013

VALUE OF WATER RESEARCH REPORT SERIES NO. 63

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Published by:
UNESCO-IHE Institute for Water Education
P.O. Box 3015
2601 DA Delft
The Netherlands

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

Please cite this publication as follows:
Hoekstra, A.Y. (2013) Wise freshwater allocation: Water footprint caps by river basin, benchmarks by product and fair water footprint shares by community, Value of Water Research Report Series No. 63, UNESCO-IHE, Delft, the Netherlands.

Acknowledgement

This report is largely based on Chapters 9 to 11 of my book *The Water Footprint of Modern Consumer Society* (Hoekstra, 2013a) and a slight expansion of an article published in *WIREs Water* (Hoekstra, 2013b). The work was partially developed within the framework of the Panta Rhei Research Initiative of the International Association of Hydrological Sciences (IAHS).

Contents

Summary

There are many river basins in the world in which human's water footprint needs to be reduced substantially. In this report, I propose three water allocation principles: environmental sustainability, resource efficiency and social equity. Linked to these three principles, I suggest three policy instruments for freshwater allocation: water footprint caps by river basin, water footprint benchmarks for water-using processes and products and fair water footprint shares per community.

Water footprint caps for all river basins in the world aim to ensure a sustainable water use within each basin. A water footprint cap sets a maximum to the water volume that can be consumed or polluted by the various human activities in a basin, accounting for the limited renewal rate of water resources and for environmental water needs.

Water footprint benchmarks for water-using processes aim to provide an incentive to producers to reduce the water footprint of their products towards reasonable benchmark levels. Benchmarks will enable the actors along supply chains – from primary producers and intermediate companies to final consumers – and governments responsible for water allocation, to share information about what are 'reasonable water footprints' for various processes and products.

Fair water footprint shares by community are necessary to ensure social equity. Water allocation may be environmentally sustainable and efficient from a resource point of view, but that does not automatically imply that water allocation is fair from a societal point of view. We need international agreement on what makes the water footprint of a community of consumers fair or reasonably acceptable, given the limited maximum sustainable water footprint per global citizen.

1. Introduction

Water pollution is normal. In China, India and Bangladesh it happens that the colour of the river shows which dye is being used in the clothes manufacturing industry (Economy, 2004; Rathore, 2011; Islam et al., 2011). In many places in the United States, atrazine concentrations in groundwater and rivers reach beyond acceptable levels due to overuse of the pesticide in agriculture (Gilliom et al., 2006). Overconsumption of water is normal as well. In several places on Earth, groundwater levels drop at alarming levels (Wada et al., 2012), in some cases, like in Yemen, by over a metre per year (Alwathaf and El Mansouri, 2012). Several rivers run dry before they flow into the sea; think of the Yellow River in China or the Colorado in the US (Molle et al., 2010).

For many people, freshwater scarcity is something that occurs 'elsewhere'. The problems, however, are closer than we may think. Our daily consumer goods are often imported from water-scarce places, so that the water consumption and pollution in remote places is partly ours. Take the UK, for instance: about 75% of the water footprint of UK consumers lies abroad (Hoekstra and Mekonnen, 2012). It's in our own interest to make water use sustainable, not only nearby, but also elsewhere, because we depend on it.

There is a growing recognition that human impacts on freshwater systems can ultimately be linked to human consumption and that issues like water shortages and pollution can be better understood and addressed by considering production and supply chains as a whole. It is increasingly acknowledged that local water depletion and pollution are often closely tied to the structure of the global economy. The global demand for water that relates to the global demand for food and other commodities is not a-priori localized in specific river basins. Water demands and supplies need to match at a global scale. This happens through the mechanism of trade (Allan, 2003). From this perspective, water is no longer a local resource, but a global resource (Hoekstra and Chapagain, 2008). Many countries have significantly externalized their water footprint, importing water-intensive goods from elsewhere (Hoekstra and Hung, 2005; Chapagain and Hoekstra, 2008; Hanasaki et al., 2010; Hoekstra and Mekonnen, 2012). This puts pressure on the water resources in the exporting regions, where, too often, mechanisms for wise water governance and conservation are lacking.

Water use in itself is not the problem, but not returning the water or not returning it clean is the problem. Therefore, the 'water footprint' doesn't measure gross water use but consumptive water use and the volume of water polluted. The conventional way of measuring freshwater use is to look at gross water withdrawals for different human activities. If one is interested in the effect of water use on water scarcity within a catchment, however, it makes more sense to look at the net water withdrawal of an activity (Perry, 2007), the so-called blue water footprint (Hoekstra et al., 2011). The blue water footprint measures the consumptive water use, that is the volume of water abstracted from the ground or surface water system minus the volume of water returned to the system. The blue water footprint thus refers to evapotranspiration in the process or incorporation of water into the product. There will also be a blue water footprint in a certain catchment when the water is returned to another catchment area or the sea. Looking at blue water consumption is not sufficient; the blue water footprint is just one component of humanity's total freshwater appropriation. The green water footprint refers to the volume of rainwater consumed in a human activity. This is particularly relevant in agriculture and forestry, where it refers to the total rainwater evapotranspiration (from fields and plantations) plus the water incorporated into the harvested crop or wood. Finally, the grey water footprint is an indicator of freshwater pollution. It is defined as the volume of freshwater that is required to assimilate a load of pollutants based on natural background concentrations and existing ambient water quality standards (Chapagain et al., 2006). It is calculated per catchment area as the load of pollutant divided by the critical load times the catchment runoff. The critical load is equal to the difference between the maximum acceptable and natural concentration of a chemical for the receiving water body times the runoff volume (Hoekstra et al., 2011).

Problems of water scarcity and pollution are not of today. Nevertheless, we haven't found ways yet to properly address them. In this report, I propose three principles for wise water use and allocation, based on my book *The Water Footprint of Modern Consumer Society* (Hoekstra, 2013a). The three allocation principles are: environmental sustainability, resource efficiency and social equity. Environmental sustainability is relevant from the geographic perspective: we should not use water within a hydrological unit beyond the carrying capacity of that unit. Resource efficiency is important from the producer perspective: since producers compete for water, it can best be used as efficient as possible, getting the highest benefit per drop and polluting the least as possible. Social equity is important from a consumer perspective: since water is a key resource for basic goods like food, drinking, energy and hygiene, every citizen in the world needs a basic share in the world's limited water resources.

In this report, I present and discuss three different policy instruments for water allocation, each one of which is directly linked to one of the allocation principles (Table 1). First, I will argue that it is vital that governments agree on "water footprint caps" for all river basins in the world, in order to ensure sustainable water use within each basin. A water footprint cap sets a maximum to the water volume that can be allocated to the various human purposes, accounting for environmental water needs. It also sets a maximum to pollution given the assimilation capacity of the basin. The total volume of 'water footprint permits' to specific users in a basin should remain below the maximum sustainable level.

Table 1. The three policy instruments for water allocation.

Perspective on allocation	Allocation principle	Policy instrument for water allocation
Geographic perspective	Environmental sustainability	Water footprint cap per river basin
Producer perspective	Resources efficiency	Water footprint benchmark per product
Consumer perspective	Social equity	Fair water footprint share per community

Second, I will argue that we need to establish "water footprint benchmarks" for the most important water-intensive products, for example for food and beverage products, cotton, cut flowers and biofuels. Water footprint benchmarks provide an incentive for producers to reduce the water footprint of their products towards reasonable levels and thus use water more efficiently. The benchmark for a product will depend on the maximum reasonable water consumption in each step of the product's supply chain. In this way, producers that use water, governments that allocate water and manufacturers, retailers and final consumers in the lower end of the supply chain, share information about what are 'reasonable water footprints' for various process steps and end products. When granting certain water footprint permits to specific users, it makes sense for governments to take into account the relevant water footprint benchmarks for the different users.

Third, I introduce the idea of a “fair water footprint share per community”. Water allocation may be environmentally sustainable and efficient from a resource point of view, but that does not automatically imply that water allocation is fair from a societal point of view. We need some common understanding of what makes the water footprint of a community of consumers fair or reasonably acceptable, given the limited maximum sustainable water footprint per global citizen. Consumers in the US and Southern Europe use about two times more water than the global average (Hoekstra and Mekonnen, 2012). We need a political debate at the international level about equitable sharing of the world’s freshwater resources. This implies that we will need to reconsider our consumption pattern.

In the next three sections, I will discuss the three policy instruments for freshwater allocation one by one. In the final section it will be argued that none of the three instruments will be sufficient in itself to secure sustainable, efficient and equitable water use. All three instruments are fundamental and complement each other.

2. Water footprint cap per river basin

Within a river basin, water resources availability is constrained by the amount of precipitation. The precipitation that adds to the water in a river basin will leave the basin again by evaporation or runoff to the ocean. The evaporative flow (green water) can be made productive in crop fields or production forests. In this way, the evaporative flow is not 'lost' to the atmosphere but productively used. The runoff flow (blue water) can be made productive as well, by withdrawing water from aquifers and rivers and using it in industries or households or for irrigating crop fields. In this way, the runoff flow is not 'lost' to the ocean, but consumed for useful purposes. We can use all the green and blue water available in a river basin in a certain period. Temporarily, we can even use more than that, by depleting groundwater and lake reservoirs but, in the longer term, from a sustainability point of view, we cannot use more than the rate of replenishment. The upper limit to consumptive water use within a river basin is the precipitation within the basin. However, this is really an upper-upper limit; the actual upper limit lies substantially lower. The 'loss' of water to the atmosphere through non-beneficial evapotranspiration and the 'loss' of water to the ocean are not real losses. These flows are essential for the functioning of ecosystems and of societies depending on those ecosystems (think of in-stream water uses like fisheries and navigation). Substantial amounts of the green and blue water flows therefore need to be maintained to support ecosystems and shouldn't be allocated to human purposes.

The upper limit to the green water footprint in a river basin is formed by the total evapotranspiration from the land that can be made sustainably available for agricultural production or forestry. As a rough indication, about 25-50% of the land has to be reserved as a natural area to sustain biodiversity (Svancara et al., 2005). Besides, areas are needed for living and infrastructure, and some areas, like deserts and steep mountains, are unsuitable for production, so that only a fraction of the land is available for agriculture and forestry. Only the green water flow in this area can be productively employed to produce food, feed, fibre crops, timber, paper, etc. Besides, only the green water in the growing season can be employed. The 'maximum sustainable green water footprint' (or shortly 'green water availability') in a river basin is only a fraction of the total evaporative flow.

The upper limit to the blue water footprint in a river basin is given by the total natural runoff from the basin minus the so-called 'environmental flow requirement'. Environmental flow requirements are the flows that need to remain in the river to sustain freshwater and estuarine ecosystems and the human livelihoods that depend on these ecosystems (Poff and Zimmerman, 2010). The idea that all runoff can be consumed without a price is wrong. Biodiversity along rivers and in river deltas obviously depends on the presence of river water. As a rough indication, about 80% of the natural river flow needs to be maintained in order to prevent major changes in natural structure and ecosystem functions along the river and in its delta (Richter et al., 2012). As a rule of thumb, the 'maximum sustainable blue water footprint' (or 'blue water availability') in a river basin is only 20% of the runoff from the basin.

For the grey water footprint, a similar sort of logic applies. The impact of water pollution depends on the size of the pollution. The 'maximum sustainable grey water footprint' in a river basin is reached when the size of the grey water footprint equals the runoff from the basin. In this case, the anthropogenic load of chemicals to the river has reached the so-called critical load, which is defined as the difference between the maximum allowable and the natural concentration of a chemical in a river × the runoff of the river (Hoekstra et al., 2011). In the USA, the concept of critical load is known under the term 'total maximum daily load'. The essence is that loads that go beyond the maximum or critical load cause an exceedance of ambient water quality standards. When the grey water footprint exceeds runoff, the waste assimilation capacity has been fully used.

In the case of the carbon and ecological footprints, it makes sense to speak about global maximum sustainable levels (Ercin and Hoekstra, 2012; WWF, 2012). This is different in the case of the water footprint. The maximum green, blue or grey water footprint will always depend on location and time. A certain blue water footprint for example may cause little change in one catchment area, while the same sized footprint can cause depletion of water in a much drier catchment area. The same difference can occur over time: while a certain blue water footprint may be considered small during a wet month, it can be considered huge in a dry month in the same catchment area. When we aggregate the blue water footprints of all human activities over all the river basins in the world and over the months in a year, we can speak about the global blue water footprint in a year, but it does not make sense to compare this global annual blue water footprint to the aggregated blue water availability in the world over the year. Water shortage in one basin cannot be crossed against water abundance in another basin; and water shortage in one specific month cannot be crossed against the abundance of water in another month. Water scarcity, water overexploitation and water pollution manifest themselves in specific areas at specific times (Hoekstra et al., 2012).

Establishing maximum sustainable water footprints per month per river basin can be regarded as a scientific challenge. It will be a political challenge to translate knowledge on maximum sustainable water footprints into agreements on practical water footprint caps per river basin. Agreeing, for example, on a blue water footprint cap would be a useful thing for all river basins in the world, although obviously most urgent for the basins where the current blue water footprint already exceeds the maximum sustainable level. Whether a river basin falls within one nation or is shared among different nations, agreeing on a blue water footprint cap is a political thing, whereby it can be expected that the level of the cap set will depend on negotiations and trading off different interests. For basins in which blue water resources are currently overexploited, it is most realistic to agree on a blue water footprint cap that gradually moves in time from the current blue water footprint level down to a level that can be regarded as sustainable. Over time, the necessary measures can then be taken to increase water-use efficiencies, so that the same levels of production can be achieved at a smaller blue water footprint. Other sorts of necessary measures may include shifting between different crops and – if otherwise impossible to meet the blue water footprint reduction target – reducing production levels altogether.

The idea of a cap on water use is not entirely new. In the Murray-Darling Basin in Australia, for example, a cap on surface water diversions was adopted as a response to growing water use and declining river health (MDBC, 2004). It was agreed that the cap be defined as 'the volume of water that would have been diverted under 1993/94 levels of development'. The question is still whether the cap puts a sufficient limit on water use to make water use really sustainable in the long term. A shortcoming of the cap in the Murray-Darling Basin is that it does not include groundwater abstractions, so that as a result of the cap on surface water diversions, the use of groundwater in the basin accelerated. Another deficiency is that the cap manages diversions rather than consumptive use.

The grey water footprint in a river basin needs to be capped as well. This is easier than finding agreement on capping the blue water footprint, because most countries already have ambient water quality standards in existing legislation. Together with natural concentrations and river runoff, this implies a certain critical load per chemical. The maximum sustainable grey water footprint in a catchment area is reached when the total load of a chemical equals the critical load; in this case, the grey water footprint is the size of the river runoff. The challenge here is to rationally translate ambient water quality standards per chemical to critical loads and agree on devising institutional mechanisms that ensure that critical loads are not exceeded. The contribution of diffuse sources of pollution should thereby not be ignored. In most basins of the world, it is still common practice that diffuse pollution (e.g. from fertilizers and pesticides used in agriculture) is not properly regulated. For point sources of pollution, it often happens that effluent standards are not strict enough given the number of effluent disposal licences issued or that illegal wastewater disposals take place. As a result, critical loads are easily surpassed.

I do not argue for setting green water footprint caps per river basin, because it is more straightforward to agree on reserving lands for nature. Indirectly, this means that the green water resources attached to these lands will not be available for crop production or forestry. In fact, by determining which lands can be used for agriculture and for forestry, one simultaneously allocates the green water resources in a basin.

Agreement on blue water footprint caps and critical loads per contaminant by river basin would be an enormous step forward in managing our global freshwater resources wisely. The problem with overdraft from aquifers and rivers and water pollution is that proper mechanisms to set limits are generally absent. Setting the limits clearly is one step towards better regulation. As a next step, the challenge will be to translate maximum water consumption levels and critical loads to limits for individual users. In international river basins, there will be the intermediate step of translating basin limits to national limits for that basin.

Water footprint caps need to be specified spatially – by river basin but also by sub-catchment – and temporally – for example by month. Specific attention will need to go to issues of inter-annual variability, because a potential trap is that limits are set for an average year, which will inevitably lead to problems in drier years. We could see this for example in the Murray-Darling Basin in Australia, where the overdraft of water in recent years has been partly blamed on that fact that water use permits to farmers were issued based on a too optimistic assessment of blue water availability. Once a blue water footprint cap for a river basin has been set, regular monitoring will be needed to evaluate whether the level of the cap is still appropriate, given changing environmental conditions like climate or improved knowledge regarding environmental flow requirements.

3. Water footprint benchmark per product

Based on the variability of water footprints found across regions and among producers within regions, for each water-using process, a certain benchmark can be established that can act as a reference and target for all producers that have water footprints above the benchmark. A benchmark is understood here as a point of reference for evaluating water use efficiency. The water footprint benchmark for a certain process can be chosen, for example, by looking for the water footprint that is not exceeded by the best 20% of the producers. This can be done on a regional basis, in order to account for differences in environmental conditions (climate, soil) and development conditions, but it can also be done on a global basis, given the fact that for each process there is some reasonable level of water productivity (water footprint) that can be achieved in every location in the world.

The idea of a water footprint benchmark can be illustrated with an example for growing cotton. The global average green plus blue water footprint of seed cotton is 3,600 litres/kg (Mekonnen and Hoekstra, 2011). The best 20% of the globally produced seed cotton, however, has a green–blue water footprint of 1,820 litres/kg or less. In Uzbekistan, the largest cotton producer in Central Asia, the green-blue water footprint is 4,426 litres/kg of seed cotton. The worst 20% of cotton production in the world has a green–blue water footprint of about 5,000 litres/kg, a value that is surpassed by producers in Turkmenistan and Tajikistan, the next most important cotton producers in Central Asia. There is nothing unique in the region that justifies such low water productivities compared to other regions in the world. If the three most important cotton producing countries in the region – with, on average, a green–blue water footprint of about 5,000 litres/kg of seed cotton – would all manage to reduce the water footprint to the global 20-percentile benchmark of 1,820 litres/kg, the region would reduce cotton-related water consumption by nearly a factor of three.

Looking at the best 20% of global production is one way of establishing water footprint benchmarks for water-consuming activities. Another way is to identify ‘best-available technology’ and ‘best water-using practices’ and take the water footprint associated with best technology and practice as the benchmark. In industry, closed water-cooling or dry cooling systems have a smaller blue water footprint (possibly zero) than open water-cooling systems and systems that recapture the heat from warm effluents have a smaller grey water footprint than systems that do not. From the perspective of ‘best-available technology’, most industries can simply move towards ‘zero water footprint’ in their operations. The blue water footprint can be brought down to zero by avoiding evaporation losses. When all water abstracted is returned to the catchment or reused, an industry has no blue water footprint. The grey water footprint can be nullified by avoiding any diffuse pollution and making sure that effluents are treated such that the concentration of any chemical is lower than in the abstracted water. Thermal pollution can be avoided by recapturing the heat from effluents before disposal. In the agricultural, forestry and mining sectors, a zero water footprint is generally impossible, although diffuse pollution (the grey water footprint) can often be avoided or greatly reduced. In the agricultural sector, organic farming or precision application of fertilizers and pesticides can greatly reduce the grey water footprint. Regarding the blue water footprint in agriculture, precision irrigation using micro-irrigation techniques is much more advanced than using sprinklers, so it can be a choice to set these techniques and the associated water footprint of the crop as a benchmark.

Benchmarks for the various water-using processes along the supply chain of a product can be taken together to formulate a water footprint benchmark for the final product. An end-product point of view is particularly relevant for the companies, retailers and consumers that are not directly involved in the water-using processes in the early steps of the supply chains of the products they are manufacturing, selling or consuming, but that are still interested in the water performance of the product over the chain as a whole.

Water footprint benchmarks for processes and products can be used in different ways. Governments can for example align water pricing schemes to benchmark levels, whereby the water price charged to users quickly rises if they use water beyond benchmark level. Alternatively, governments can simply deny permits to users that would allow these users to have a water footprint beyond benchmark level. Water footprint benchmarks for different water-using processes can be useful as a reference for farmers and companies to work towards. Specific industrial sectors can voluntarily set benchmark levels for their processes and products, and individual companies can have their own corporate reference and target levels. Companies may use benchmarks in their sustainability reporting and governments can develop regulations that force companies to communicate to which extent they are away from reaching certain benchmark levels. The extent to which certain benchmark levels have been reached can also be part of certification and labelling schemes.

Efficient production in a finite world

One could argue that regulating the maximum water footprint per basin would be a sufficient measure, since it would automatically translate into an incentive to use water more efficiently and put a constraint to consumption. The geographic focus, however, is insufficient, as I will illustrate here through a simple example.

Suppose the hypothetical case of two river basins, with the same surface (Table 2). Basin A is relatively dry and has, on an annual basis, 50 water units available, the maximum sustainable water footprint. The maximum level, however, is exceeded by a factor of two. Farmers in the basin consume 100 water units per year to produce 100 crop units. Basin B has more water available, 250 water units per year. Water is more abundant than in the first basin, and water is used less efficiently. Farmers in the basin consume 200 water units per year, to produce 100 crop units, the same amount as in the first basin, but using two times more water per crop unit. A geographic analysis shows that in basin B, the water footprint (200) remains below the maximum level (250), so this is sustainable. In basin A, however, the water footprint (100) by far exceeds the maximum sustainable level (50), so this is clearly unsustainable. The question is now: should we categorize the crops originating from basin A as unsustainable and the crops from basin B as sustainable? From a geographic perspective, the answer is affirmative. In basin A, the water footprint of crop production needs to be reduced, that seems to be the crux. However, when we take a product perspective, we observe that the water footprint per crop unit in basin B is two times larger than in basin A. If the farmers in basin B would use their water more productively and reach the same water productivity as in basin A, they would produce twice as many crops without increasing the total water footprint in the basin. It may well be that farmers in basin A cannot easily further increase their water productivity, so that – if the aim is to keep global production at the same level – the only solution is to bring down the water footprint in basin A to a sustainable level by cutting production by half, while enlarging production in basin B by increasing the water productivity. If basin B manages to achieve the same water productivity level as in basin A, the two basins together could even increase global production while halving the total water footprint in basin A and keeping it at the same level in basin B.

Table 2. Example of how overexploitation in a water-stressed river basin (A) can be solved by increasing water productivity in a water-abundant basin (B).

Parameter	Unit	Current situation		Possible solution	
		Basin A	Basin B	Basin A	Basin B
Max. sustainable water footprint	Water units / unit of time	50	250	50	250
Water footprint	Water units / unit of time	100	200	50	200
Production	Product units / unit of time	100	100	50	200
Water footprint per product unit	Water units / product unit	1	2	1	1
Water productivity	Product units / water unit	1	0.5	1	1

This example is not a theoretical one. In the real world we can see a lot of semiarid regions where water is relatively efficiently used, but overexploited, while we see water-abundant regions, where no overexploitation takes place but where water productivities are comparatively low. From a geographic perspective, the weak spots in the whole system lie in the regions with water overexploitation, where the total water footprint is too large. From a production perspective, the weak spots in the system lie in the regions with low water productivities, where water footprints per unit of production are unnecessarily large. In order to move the whole system in a sustainable direction, two things need to happen at the same time: total water footprints need to be reduced in the geographic areas where maximum sustainable levels are exceeded and water footprints per unit of production need to be reduced in those areas where this can be achieved most easily. From a global perspective, sustainability requires that maximum water footprint levels for all individual geographic areas are maintained but, in order to achieve that, water-use efficiencies need to be improved everywhere, wherever feasible, also in regions where water is abundant. From this global perspective, a product cannot be considered sustainable simply because it was produced in an area where maximum water footprint levels are maintained. Given certain global demands for various products and given global constraints to water availability, water footprints per unit of product need to remain within certain limits. In practice, an important part of the solution to overexploitation of blue resources in water-scarce catchments, is to use green water resources more productively in water-abundant catchments. Even though many people, including most water professionals, are inclined to focus on the main problem (irrigated agriculture in dry regions) and look for solutions there (increase blue water productivity), an essential element of the global solution is to invest in increasing productivities in rain-fed agriculture in wet regions (increase green water productivity) (Falkenmark and Rockström, 2004).

The above shows that one should be careful with a focus on efficient use of water resources in the water-scarce areas alone. A significant part of the solution of water scarcity experienced in various places lies in using water more efficient in water-abundant parts of the world.

4. Fair water footprint share per community

At the start of the twenty-first century, the average world citizen had a water footprint of 1,385 m^3/yr (Hoekstra and Mekonnen, 2012). There are, however, big differences between and within countries. The average consumer in the United States had a water footprint of 2,842 m^3/yr, whereas the average citizens in China and India had water footprints of 1,071 and 1,089 m^3/yr, respectively. The global total has brought us where we are now: overexploitation of blue water resources in roughly half of the world's river basins (Hoekstra et al. 2012) and pollution beyond assimilation capacity in at least two-thirds of the river basins in the world (Liu et al., 2012). We can try to shift the burden to some extent from overexploited to not-yet overexploited river basins to find better regional balances between water consumption and water availability and between water pollution and waste assimilation capacity. In this way we may be able to better accommodate our current global water footprint. It is hard to imagine, however, that an increase of the current global water footprint can work out sustainably.

According to the medium population scenario of the United Nations, the world population is expected to increase from 6.1 billion in the year 2000 to 9.3 billion in 2050 and 10.1 billion by the end of this century (UN, 2011). This means that, if we want to make sure that the water footprint of humanity as a whole will not increase over the coming century, the average water footprint per capita will have to decrease from 1,385 m^3 in 2000 to 910 m^3 in 2050 and 835 m^3 in 2100. If we assume an equal water footprint share for all global citizens, the challenge for countries like China and India is to reduce the current water footprint per capita level by about 22.5% over the 21st century. For a country like the USA, it means a reduction of the average water footprint per capita by about 70%. Improved technologies alone will not be sufficient to reach this goal.

There is an urgent need to evaluate the sustainability of current consumption patterns in the light of limited freshwater resources and a growing world population. Since about 29% of the water footprint of humanity relates to growing feed for farm animals (Hoekstra and Mekonnen, 2012), addressing the level of meat and dairy consumption will be one of the key issues. The second most important issue is probably to address the growth of water use for growing crops for biofuels (Gerbens-Leenes et al., 2012). Wise water policies for the future will definitely need to include meat and biofuel paragraphs.

How can developing countries like China and India grow economically without enlarging their water footprint per capita or even while reducing it? In India, where meat consumption is relatively low, the government should try and keep it that way. The major challenge will be to reduce water consumption in cereal production. In China, the number-one concern should be meat consumption. In both countries, policies should aim at reducing food waste and developing industries with best-available technology, so that industrial development will not go hand in hand with an industrial water footprint as we can see in industrialized countries. For most of the developing countries, the challenge is threefold: improving water productivities in agriculture; ensuring that industrial developments are based on best-available technology; and staying with or moving towards low-meat diets.

The challenge in the industrialized world is probably even bigger than in the developing world. Taking the UN's medium population growth variant and assuming that all countries will need to move towards a fair share in the global water footprint of humanity, countries like the USA, Canada, Australia, Spain, Portugal, Italy and Greece will need to reduce their water footprint per capita roughly by a factor of three in the period 2000-2050. If those countries will not move towards their fair share, it means that the water footprint of humanity will inevitably increase, since it is hard to imagine that developing countries will compensate. The idea of a 'fair share' is challenging and probably difficult to accept for many countries that currently have a water footprint per capita beyond the global average.

Equitable consumption in a finite world: the need for contraction and convergence

The limited availability of freshwater in the world implies a ceiling for humanity's water footprint. The question for the global community is how this global maximum can be transferred to the national or even the individual level. In other words: what is each nation's and each individual's 'reasonable' share of the globe's water resources? And what mechanisms could be established in order to make sure that people do not use more than their 'reasonable' share? Maximum levels of water consumption and pollution to guarantee a sustainable management of the world's freshwater resources could be institutionalized in the form of an international agreement on 'water footprint allowances' specified per nation. Such a 'water footprint allowance' would be the total water footprint that the consumers within a nation are allowed to have within the international agreement. The allowance would reflect the share that the consumers within a nation have in the total water footprint of humanity. The levels of the allowances per country would need to be negotiated among countries, and will therefore probably lie somewhere between the country's current water footprint levels and the fair share per country based on population numbers.

Politically, different steps are to be taken. First, national governments need to reach consensus about the need to halt the continued growth of the water footprint of humanity as a whole. Second, given projected increases in the global population, international consensus needs to be reached about water footprint reduction targets or maximum water footprint increase levels per country. Third, nations would be responsible for translating the national reduction targets into national policy in order to meet the target. Enforcement could be done in the form of penalties when not meeting the agreed targets. Targets would need to be specified, for example, by water footprint component (green, blue, grey water footprint); they could also be specified by sector or product category. Obviously, water footprint allowances or reduction targets could develop over time and would need to be negotiated on a regular basis, like every ten years or so. The similarity with international negotiations about carbon footprint reductions is clear (Box 1).

The need to establish water footprint caps in combination with the idea of fair water footprint sharing is comparable to what has been called the need for 'contraction and convergence'. This means that equal per capita allowances are established under an ecological cap that converges towards a sustainable level (Jackson, 2009). The idea of 'contraction and convergence' was conceived in the mid-1990s by the Global Commons Institute (GCI) in London as a mechanism to reduce the global carbon footprint to a safe and sustainable level per person within the next few decades (Meyer, 2004). Overall emissions should 'contract' to a level compatible with the stabilization target, and per capita emissions 'converge' towards an equal per capita share of the overall emissions budget. As Jackson (2009) puts it, the idea of 'contraction and convergence' is a way of transparently structuring future negotiations on the understanding that prosperity is governed by ecological limits on the one hand and fair shares on the other.

Box 1. Reducing the global water footprint versus reducing the global carbon footprint.

An international agreement on water footprint allowances or water footprint reduction targets per nation would be somehow comparable to the Kyoto Protocol on the emissions of greenhouse gases (UN, 1998). The Kyoto Protocol – which was drafted in 1997 and became effective in 2005 – is based on the understanding that, to prevent human-induced climate change, a maximum is to be set to the volume of greenhouse gas emissions from human activities at the global level. The protocol is an international agreement to cut greenhouse gas emissions, with specific reduction targets by country. The overall goal was a collective reduction of greenhouse gas emissions by 5.2% in 2012 compared to the reference year of 1990. The experience with the Kyoto Protocol is both hopeful and discouraging. The good side of the experience is that the global community has shown that it is able to collaborate towards a common interest, but the downside is that the agreement did not have reach and teeth enough to be really effective: humanity's carbon footprint has continued to increase (Olivier et al., 2012). It would be good if, in the global talks about addressing the global water footprint, lessons were drawn from the experience with the Kyoto Protocol (Ercin and Hoekstra, 2012). Simply adopting the same sort of format, with tradable emission credits, seems to be a bad idea, because the possibility of offsetting offers an escape route away from actual footprint reduction. We have to acknowledge that, after all, the idea of offsetting is not such a good idea as it seemed at the time it was invented. The achievement of the Kyoto Protocol is the establishment of the whole idea of setting concrete footprint reduction targets by nation. With hindsight, however, we can conclude that the mechanisms that were installed to reach those reduction targets are flawed. Another flaw of the Kyoto Protocol is that greenhouse gas reduction targets are related to the carbon footprint of production in a country, not the carbon footprint of consumption in a country. This can lead to the situation in which a country externalises its carbon footprint of consumption to other countries, in this way meeting the reduction target for the carbon footprint created within its own territory, but not changing the root cause of the footprint, which is consumption.

The idea of 'contraction and convergence' for the case of humanity's water footprint is illustrated in Figure 1. Humanity's water footprint as in the year 2000 has been assumed as the maximum sustainable water footprint. The maximum sustainable water footprint per capita will decrease over time due to population growth. In the coming century, the water footprint per consumer in the US should decrease by about 70% compared to the reference level in 2000, in order to stabilize on the level of a fair share in the maximum sustainable water footprint in the world. The consumers in a country like China may initially slightly increase their water footprint per consumer, but will need to stabilize soon as well.

It can be foreseen that international negotiations on water footprint reduction targets by country will be incredibly difficult. The interest in international water footprint reduction targets is greatest with communities facing severe water shortages; these communities rely on water resources elsewhere (since they have to import water-intensive commodities) and will benefit if communities elsewhere reduce their water footprint of consumption. If consumers in water-abundant regions consume less water-intensive products and use water resources more efficiently, more water resources will remain for producing water-intensive products for export to water-poor countries. The power in the negotiations is thus with the water-abundant countries. Entering into an international agreement to reduce water footprints per capita is least attractive for nations that are not very water scarce and have a relatively large current water footprint per capita. It is most attractive – and in fact vital – for nations that are highly water scare, whatever is their current water footprint per capita.

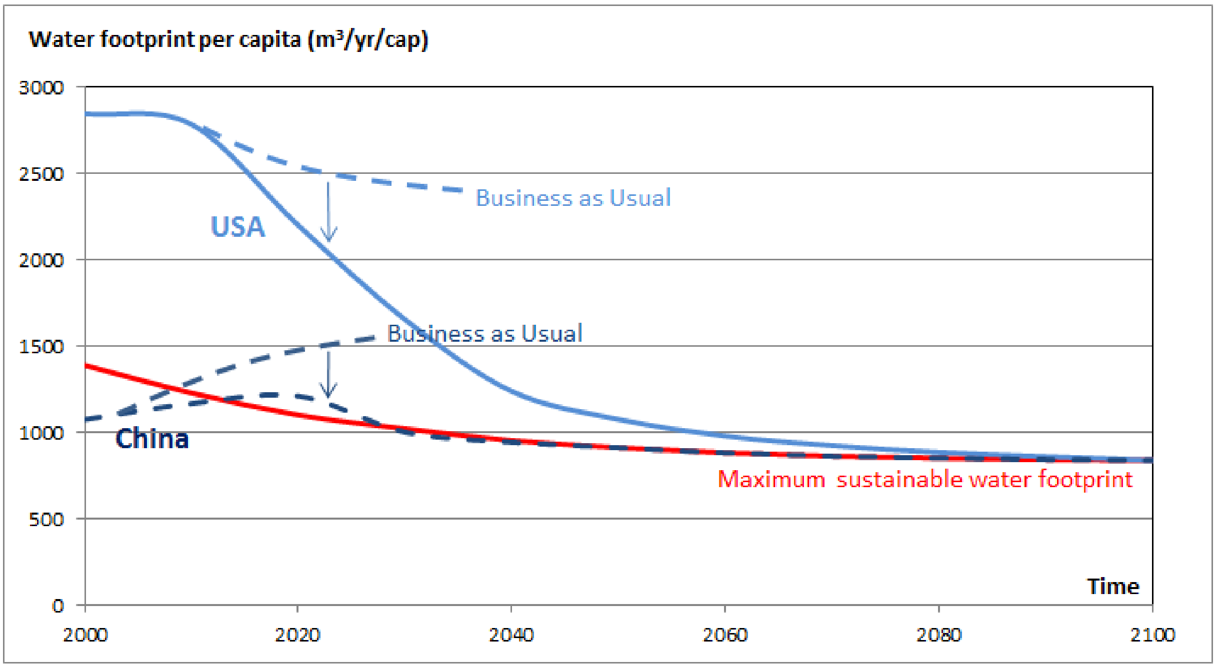

Figure 1. Convergence of the consumption patterns in different countries towards an equal share in the maximum sustainable global water footprint. The maximum sustainable global water footprint per capita declines in time due to projected population growth (UN medium scenario). In the case of Business as Usual (BaU), the water footprint in the US expectedly declines somewhat due to water-use efficiency increases, but not to the degree required for equal water sharing. In the BaU scenario, the water footprint per capita in China will increase and stabilize at a level far beyond the sustainable equal share level.

5. Freshwater allocation: dividing the annual budget among producers and consumers

When water managers speak about water allocation, they usually talk about the allocation of water to different producers of goods or services that require water in their production process and possibly bring along some type of water pollution as well. It makes sense, though, to look at the indirect allocation of water as well. If water is allocated to a soybean farmer who exports the soybean as animal feed, the water has been indirectly allocated to a meat eater abroad. The question is whether this is a priority in water allocation in the country of the soybean farmer. The same sort of question can be posed if water is allocated to a maize farmer who produces for the bioenergy market. The indirect allocation is quite relevant from a consumer perspective: who will ultimately benefit from the water? The allocation of water to producers of water-demanding goods and services is generally done at the level of river basins. The allocation of water to final consumers is much less visible, because water is not explicitly allocated to consumers, since this happens implicitly through the goods and services that consumers buy. Indirect water allocation to final consumers occurs at a global level, because goods can be internationally traded.

As already stated in the introduction, there are three different perspectives on water allocation. From the geographic perspective, the question is: what is the maximum water footprint that can be allocated? This means: what is the maximum amount of permits to consume or pollute water that can be allocated to producers? From the perspective of the producers, the question is: how will water footprint permits be divided over competing users? From the perspective of final consumers, the question is: how will the total water footprint in the end be divided among consumers? The annual budgets that can be divided by river basin, initially among producers and in the end among consumers worldwide, are limited. Water footprint caps by river basin are aimed to define the size of the available annual budget to be divided.

Increasing efficiency or adjusting lifestyles

There are two ways to remain within the maximum sustainable global water footprint: increase water productivities, so that producers can produce the same but at a smaller water footprint, or adjust lifestyles, so that the same well-being is obtained but with lower consumption of the most water-intensive goods. Generally, we can see a focus on efficiency improvement as the ultimate panacea. Although in many water-using processes huge gains can be made by increasing efficiency (producing the same with less water consumption and pollution), one should be cautious for an over-optimistic expectation of the environmental gains of increased water-use efficiency as well. From energy studies, we know a phenomenon that is called the 'rebound effect' (Binswanger, 2001; Sorrell et al., 2009; Terry et al., 2009). Rebound refers to a typical response in the market to the adoption of new techniques that increase the efficiency of resource use. The typical response is that if resources are saved, they become available for additional production, so that in the end the original environmental gain is partly or completely offset. Sometimes, consumption even increases (rather than decreases) as a result of the efficiency increase. This specific case of the rebound effect is known as the Jevons paradox. There are only a few studies on the rebound effect in the field of freshwater use, but there is no reason to assume that it does not occur in this sector (Ward and Pulido-Velazquez, 2008; Crase and O'Keefe, 2009).

Imagine those vast areas in the world where land is readily available, but water isn't. If a farmer is used to pumping water for irrigating his land and finds out that he can obtain the same yield with less water, he may well decide to irrigate more land, thus increasing his total production, using more efficient irrigation techniques but in total the same volume of water. It is not extraordinary to assume that water productivity increases in food supply will facilitate an even quicker shift to the production of biofuels.

Establishing maximum water footprints per river basin, providing incentives to lower water footprints of products to reasonable benchmark levels and changing our consumption patterns to less water-intensive will be complementary measures to drive to sustainable, efficient and equitable water use. Since allocation of water is essentially political, it is time that politicians put water scarcity and water allocation higher up on their agendas.

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