are independent and barley is only one of their crops, we at SABMiller sought to gain a better understanding of the socio-economic and environmental effects of engaging with the farmers, mainly because of the increasing concerns about water scarcity in the region. Under different scenarios, the study assessed trends in agriculture in Rajasthan over the last 10 years and found that production was characterized by increasing fertilizer and fossil fuel use (the latter used to produce energy), and limited water-use reductions. Comparing the performance of barley farmers with these trends, the study showed that SABMiller's programme helped participating farmers to increase yield by 55%, produce a better quality barley, increase their income by US$1 per day by following the best agronomic advice for malting barley, achieve a fourfold reduction of irrigation water use and reduce their carbon emissions by 16%.

For the 6,000 participating farmers in Rajasthan, the annual reduction of water use and CO_2 emissions amounted to 3.4 million m^3 and 1,980 tonnes of CO_2 equivalent, respectively. The total monetary value of these normally unpriced effects was estimated at US$300,000 per year. This means that without the programme, barley production would have had an additional annual (hidden) cost of US$300,000 — representing the cost of depleting water resources and contributing to climate change. Despite these water and carbon benefits, the study highlighted two areas for potential improvement. First, even larger reductions in water use are needed. The aquifer in the area suffers from unsustainable extractions for agricultural activities. Barley is just part of the picture and wider systemic changes to the entire agricultural system are needed to address the rapid fall in groundwater resources. Second, wider support is required for growers to improve their farming practices. Farmers could achieve an increase in their income by US$2 per day if they systematically received best-practice agronomic advice for all current crops, not just barley.

Resource interconnectivity

The lessons we at SABMiller have learned from this valuation study of malting barley is that inter-connections between resources are critical and issues such as water scarcity and food and energy security cannot be addressed in silos. We need to find better ways to address the physical impacts of climate change and handle the relationships and trade-offs between water, food and energy. Furthermore, these challenges are compounded by the societal impacts of the local political economy of water. Therefore, we are now trying to make our own business decisions through the lens of the resources nexus. In doing so, we are working to expand our global network of local partnerships to foster sustainable solutions[2].

Wasteful resource use impacts on natural capital and can undermine long-term economic and social stability, exacerbating risks for businesses. We share the risks related to these resources with local communities and other stakeholders, such as governments and NGOs. This means that collective understanding and collective action are crucial. In India, water scarcity is a major issue and we are determined to collaborate with all those affected to understand and tackle the problem to benefit local communities and ecosystems, as well as our business. Effective resource management can also generate opportunities for businesses and other stakeholders to counteract the impacts of climate change.

Assessing and pricing externalities is not an easy task, nor is it an established business practice, but we at SABMiller believe it is a valuable tool for supporting better resource management. Increased use of externality valuation represents an important step in the journey towards factoring natural capital into business decisions. ❐

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COMMENTARY:

Water scarcity challenges to business

Arjen Y. Hoekstra

The growing scarcity of freshwater due to rising water demands and a changing climate is increasingly seen as a major risk for the global economy. Consumer awareness, private sector initiatives, governmental regulation and targeted investments are urgently needed to move towards sustainable water use.

Recently, the World Economic Forum listed water scarcity as one of the three global systemic risks of highest concern, an assessment based on a broad global survey on risk perception among representatives from business, academia, civil society, governments and international organizations[1]. Freshwater scarcity manifests itself in the form of declining groundwater tables, reduced river flows, shrinking lakes and heavily polluted waters, but also in the increasing costs of supply and treatment, intermittent supplies and conflicts over water. Future water scarcity will grow as a result of various drivers: population and economic growth; increased demands for animal products and biofuels; and climate change[2]. Water-use efficiency improvements may slow down the growth in water demand but, particularly in irrigated agriculture, such improvements will most likely be offset by increased production. Similarly, water storage and transfer infrastructure improve availability, but allow further growth in demand as well. Climate change will probably increase the magnitude and frequency of droughts and floods. The expected increase in climate variability will compound the problem of water scarcity in dry seasons by reducing water availability and increasing demand, the latter owing to higher temperatures and the need to make up for lost precipitation[3]. The private sector is becoming aware of the problem of freshwater scarcity but is facing the challenge of formulating effective responses.

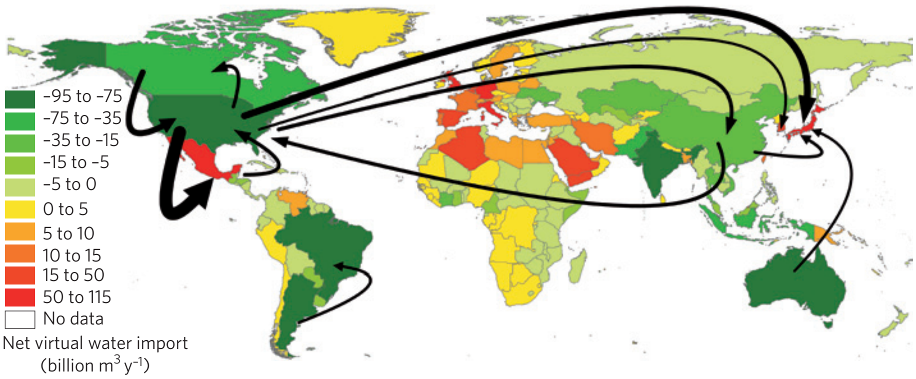

Figure 1 | Virtual water balance per country and largest virtual water flows related to international trade. In the countries coloured green, water use for producing export commodities exceeds the water use behind imported products (net virtual water export). In the countries coloured yellow to red, the opposite is true (net virtual water import). The thickness of the arrows represents the comparative quantity of water being traded. Figure reproduced with permission from ref. 6, © 2012 NAS.

Water risk

Water shortage and pollution pose a physical risk to companies, affecting operations and supply chains[4]. They also face the risk of stricter regulations; what form these will take — for example, higher water prices, reduced rations, stricter emission permits or obligatory water-saving technology — remains unclear. Furthermore, brands face a reputational risk because the public and media are becoming increasingly aware that many companies contribute to unsustainable water use[5]. Even companies operating in water-abundant regions can be vulnerable to water scarcity, because the supply chains of most companies stretch across the globe. An estimated 22% of global water consumption and pollution relates to the production of export commodities[6]. Countries such as the USA, Brazil, Argentina, Australia, India and China are big virtual water exporters, which means that they intensively use domestic water resources for producing export commodities (Fig.1). In contrast, countries in Europe, North Africa and the Middle East as well as Mexico and Japan are dominated by virtual water import, which means that they rely on import goods produced with water resources elsewhere. The water use behind those imported goods is often not sustainable, because many of the export regions overexploit their resources.

Many companies — particularly multinationals — have started to assess their water risk and in the near future we may expect to see an increasing number of them developing response strategies. At best, however, this will only partially mitigate the problem of water scarcity. A critical perspective is that corporate engagement on water is a cynical attempt by businesses to extend control over the resource or just an effort to maintain a favourable brand image[7]. A more optimistic perspective is that an increasing number of companies are genuinely concerned about growing water scarcity and looking for mitigating strategies, but even then it is unlikely that economies will structurally change without governmental regulation. The reason for this is that water is a public good, vulnerable to free-rider behaviour, and water scarcity and pollution remain unpriced. Water use is subsidized in many countries, either through direct governmental investments in water supply infrastructure or indirectly by agricultural subsidies, promotion of crops for bioenergy or fossil-energy subsidies to pump water.

Water stewardship

Managing water risk is generally confused with good water stewardship. The former can contribute to the latter, but water stewardship entails more than managing water risk. Water stewardship includes the evaluation of the sustainability of water use across the entire value chain, the formulation of water consumption and pollution reduction targets for both the company's operations and supply chain, the implementation of a plan to achieve these targets and proper reporting on all of this. In priority catchments, it requires the pursuit of collective action and community engagement[8–10]. Large priority river basins are, for example, the Colorado and San Antonio basins in North America, the Lake Chad, Limpopo and Orange basins in Africa, the basins of the Jordan, Tigris, Euphrates, Indus, Ganges, Krishna, Cauvery, Tarim and Yellow rivers, the Yongding River basins in Asia and the Murray–Darling basin in Australia[11]. For most companies, moving towards a sustainable supply chain is a much bigger challenge than greening their own operations, because the water footprint of the supply chain is often up to a hundred times bigger than the company's operational footprint and can be influenced only indirectly. Common reduction targets in the beverage industry, such as going from 2 to 1.5 litres of water use in the bottling plant per litre of beverage, have little effect on the larger-scale given that the supply-chain water footprint of most beverages is of the order of 100 litres of water per litre of beverage, or even more[12].

Companies should strive towards zero water footprint in industrial operations, which can be achieved through nullifying evaporation losses, full water recycling and recapturing chemicals and heat from used water flows. The problem is not the fact that water is being used, but that it is not fully returned to the environment or not returned clean. The water footprint measures exactly that: the consumptive water use and the volume of water polluted. As the last steps towards zero water footprint may require more energy, the challenge will be to find a balance between reducing the water and the carbon footprint. Furthermore, companies should set reduction targets regarding the water footprint of their supply chain, particularly in areas of great water scarcity and in cases of low water productivity. In agriculture and mining, achieving a zero water footprint will generally be impossible, but in many cases the water consumption and pollution per unit of production can be reduced easily and substantially[13].

Reporting and transparency

The increasing interest in how companies relate to unsustainable water use calls for greater transparency on water consumption and pollution. Openness is required at different levels: the company, product and facility level. Driven by environmental organizations and the investment community, businesses are increasingly urged to disclose relevant data at company level on how they relate to water risks[14]. Simultaneously, there is an increasing demand for product transparency through labelling or certification. Despite the plethora of existing product labels related to environmental sustainability, none of these includes criteria on sustainable water use. Finally, there is a movement to develop principles and certification schemes for sustainable site or facility management, such as the initiatives of the European Water Partnership and the Alliance for Water Stewardship. But despite progress in awareness, still hardly any companies in the world report on water consumption and pollution in their supply chain or reveal information about the sustainability of the water footprint of their products.

Much confusion exists as to what needs to be measured and reported. Traditionally, companies have focused on monitoring gross water withdrawals and compliance with legal standards. However, net water withdrawal (the part of gross withdrawal that does not return to the water body from which the water was withdrawn, often referred to as 'consumptive water use' or 'blue water footprint') is more relevant than gross withdrawal, and meeting wastewater quality standards is not enough to discard the contribution to water pollution made by a company. Regarding terminology and calculation standards, the Water Footprint Network — a global network of universities, non-governmental organizations, companies, investors and international organizations — developed the global water footprint standard[15]. The International Organization for Standardization is developing a reporting standard based on life cycle assessment[16]. Both standards emphasize the need to incorporate the temporal and spatial variability in water footprints and the need to consider the water footprint in the context of local water scarcity and water productivity. In practice, companies face a huge challenge in tracing their supply chain. Apparel companies, for example, have generally little idea about where their cotton is grown or processed, yet both cotton growing and processing are notorious water consumers and polluters. It is difficult to see quick progress in the field of supply-chain reporting if governments don't force companies to do it.

Water allocation

Despite good efforts undertaken by several companies, it is unlikely that the business sector as a whole will sufficiently regulate itself. There is an urgent need for governmental regulation and international co-operation. Governments should develop monthly water footprint caps for all river basins in the world to ensure sustainable water use within each basin[12]. A water footprint cap sets a maximum water volume that can be allocated to different competitive purposes, accounting for environmental water needs and climate variability. It also sets a maximum water pollution given the assimilation capacity of the basin. In some basins, caps will probably reduce over time if climate change reduces water availability. The total volume allocated to specific users by water footprint permits should remain below the maximum sustainable level. Furthermore, when allocating certain water footprint permits, governments should take into account what is reasonable water use. We need to establish water footprint benchmarks for water-intensive products such as food and beverages, cotton, flowers and biofuels. The benchmark for a product will depend on the maximum reasonable water consumption in each step of the product's supply chain, based on best available technology and practice. 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. Finally, users should pay for their pollution and consumptive water use, with a differentiated price in time and space based on water vulnerability and scarcity.

Future developments

The technology required to use water resources more efficiently is available and the costs involved are not prohibitive on the macroscale. One study[17] estimated that by the year 2030 the global incremental capital investment needed to close the water resource availability gap would be less than 0.1% of the current gross world product. The challenge is to create incentives for the required investments, particularly in rising yields in rain-fed crops and increasing water productivity in irrigated agriculture. Challenges alongside improving eco-efficiency are to set bounds to the continued increase in water demands for meat and biofuels and to adapt to changing patterns in water scarcity. Another study[18] found that climate-driven changes in evaporation, precipitation and runoff will result in a 40% increase in the number of people living under absolute water scarcity conditions (with an availability of less than 500 $m^3\ yr^{-1}$). Water-scarce regions like western USA, northwest India, north China and southeast Australia still apply great volumes of water to producing export commodities, whereas water-abundant northern Europe imports a lot of its water-intensive commodities[6]. Changing patterns of water availability will influence the future spatial patterns of production of, and trade in, food, feed and biofuels and create new geographic water resource dependencies. ❐

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Correction

In the Commentary 'No pause in the increase of hot temperature extremes' (*Nature Climate Change* **4,** 161–163; 2014) references 12 and 18 were incorrect, and should have appeared as:

12. IPCC, 2012: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (eds Field, C. B. *et al.*) (Cambridge Univ. Press, 2012).

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These have now been corrected in the HTML and PDF versions after print 25 March 2014.