Chapter 18 *

Global food and trade dimensions of groundwater governance

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ABSTRACT

About 22% of water use in the world is for producing export products. The overdraft of many aquifers is partially related to incentives to produce for the world market and the fact that water scarcity is not properly priced and therefore not reflected in the price of traded commodities. This chapter aims to discuss the relation between the global economy and unsustainable water use, with a focus on groundwater and global food demand. Unsustainable groundwater use isn't a local problem only, because increasingly global markets and companies and consumers worldwide depend on the products derived from unsustainable water supplies. There is a need to collaborate internationally in introducing forces or incentives to drive towards more sustainable groundwater use. Possible arrangements discussed are an international water pricing protocol, but also the institutionalization of groundwater footprint caps that reflect maximum sustainable abstraction levels and an international product label reflecting sustainability of water use.

18.1 INTRODUCTION

Groundwater is generally used locally. Water is too bulky to make transport over large distances economically feasible. There are exceptions, like for instance the Great Man-Made River project in Libya, designed to transfer fossil groundwater pumped from the Nubian Sandstone Aquifer beneath the desert in the south of the country to the northern coastal strip, for both urban and agricultural water supply, using a pipeline network of thousands of kilometres with a planned transport capacity of 6.5 million m^3 per day when fully completed (Sternberg, 2016). This, however, is an exception and luckily so given its unsustainable character. River water is generally used locally as well, although the number of examples of large-scale long-distance inter-basin water transfers of river water is bigger than for groundwater (Ghassemi and White, 2007). A disadvantage of groundwater is that it has to be pumped from the beginning, while surface water at least comes at surface level, with the possibility to use gravity to bring water from locations at higher to locations at lower altitude. In the end, however, inter-basin transfers of river water are generally accompanied with larger energy costs for pumping as well – the California State Water Project for instance uses 2 to 3% of all electricity consumed in the state (Cohen *et al.*, 2004). Water thus largely remains a resource available

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for local use only, say within a radius of ten to hundred kilometres. Probably more accurately stated, given the natural containment of freshwater within aquifers and river basins, one could argue that the use and availability of deep groundwater resources can best be studied at the geographic level of an aquifer, while the use and availability of interlinked groundwater – river water resources can best be studied at the geographic level of a river basin. But whatever is the precise scale used – that of an aquifer or river basin – the geographic scale remains far below the continental scale. Despite this, water is nowadays increasingly regarded as a *global* resource. How can that be? In addition, proposals are made to come to global arrangements around sustainable water use (Hoekstra, 2011). Why would a resource available for local use only need to be governed at a level beyond the local level?

Water is a global resource since an estimated 22% of water use in the world is for producing export products (Hoekstra and Mekonnen, 2012). There are many specific locations were close to 100% of the water is used for making export products. Consider for instance the use of groundwater from the Ica-Villacurí aquifer beneath the desert of the Ica Valley in Peru to produce asparagus for export to Europe (Hepworth *et al.*, 2010). The farmers in Ica can be characterized as sophisticated players in the global agriculture industry. The majority of land in the Ica Valley is farmed by large agro exporters, with more than 150 hectares per plot of land each, whose crops are primarily destined for export markets. They use sophisticated irrigation techniques and are at the forefront of agricultural innovation in Peru (Bullock, 2015). But growers are pumping water from the aquifer at a much faster rate than the recharge rate: according to the Local Water Authority, water withdrawals in 2013 exceeded recharge by a factor 1.8 for the Ica aquifer and by a factor 3.6 for the Villacurí aquifer.

Local water pollution for producing export products is as common as local water consumption for making export products. Take the example of vast pollution of both groundwater and surface water resources in India in relation to fertilizer and pesticides use in cotton growing for export (Chapagain *et al.*, 2006; Safaya *et al.*, 2016) or the water pollution with toxic effluents from the cotton processing industry in Bangladesh (Islam *et al.*, 2011). These examples show that if we try to understand local patterns of water use and pollution, we will often learn that they are driven by factors in the global economy. The rules of the global economy are apparently such that there is a lack of incentives to prevent overconsumption and pollution of water. Indeed, water scarcity generally remains unpriced – users generally pay for the energy, labour, etcetera to supply the water, but not for the water itself – and regulations or enforcement to ban unsustainable water use are generally lacking or insufficient.

In this chapter, I aim to show the relation between the global economy and unsustainable water use, with a focus on groundwater and global food demand, and I will point at the need and opportunities to collaborate internationally in introducing forces or incentives to drive towards more sustainable groundwater use. In the next section I will go a bit more in depth into the phenomenon of virtual water trade – the phenomenon that water resources used in the production of commodities for export are virtually traded as well. In the third section, I discuss the issue of unsustainable groundwater use in relation to trade. The fourth section addresses the implications of differences in national water endowments for international trade. In the fifth section, I argue that international cooperation in groundwater governance seems necessary to break through the lock-in situation whereby countries keep failing to properly translate

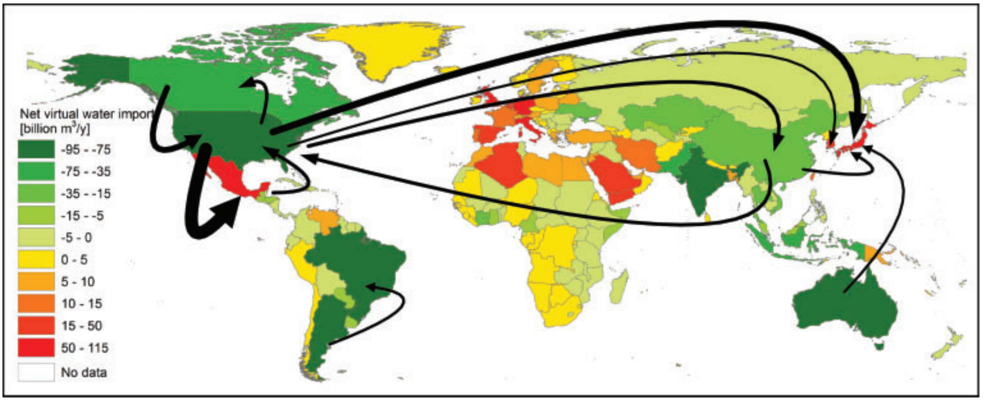

Figure 18.1 Virtual water balance per country and direction of gross virtual water flows related to trade in agricultural and industrial products over the period 1996–2005. Only the biggest gross flows (>15 billion m^3/y) are shown. Source: Hoekstra and Mekonnen (2012).

water scarcity into a price or put serious limitations to growing water use even in the most obvious cases of water depletion.

18.2 INTERNATIONAL AND INTERREGIONAL VIRTUAL WATER TRADE

The total amount of international virtual water flows has been estimated to amount 2320 billion m^3/y, of which about 300 billion m^3/y were blue water resources (Hoekstra and Mekonnen, 2012). Figure 18.1 shows the virtual water trade balance per country as well as the largest international virtual water flows.

The biggest gross virtual water exporters – using substantial portions of domestic water resources for producing export products – are the US, China, India, Brazil, Argentina, Canada and Australia. The degree to which the export commodities from these countries depend on groundwater differs. In most crop production in the world, rain is the primary source of water. Whether crops are irrigated with groundwater or surface water varies between and within countries, and similarly for water use in industries and for municipal water supply. Whether the water use for producing export products depends on renewable or non-renewable water supplies and whether they impact on flows necessary to maintain the functioning of ecosystems differs from place to place as well. The opposite of the virtual water exporters are the importers: Europe, North and Southern Africa, the Middle East, Mexico and Japan. In these regions, consumption partly depends on water resources use elsewhere. About forty percent of Europe's water footprint, the water use associated with the production of all commodities consumed in Europe, lies outside the continent, in countries like Brazil, Argentina, the US, China, India, Indonesia, and Turkey. Some of the international virtual water flows move from water-rich to water-poor countries, but other flows move from water-poor to water-rich countries. Northern Europe, for example, is relatively water abundant, but its consumption relies on substantial volumes of water use in regions where water is much scarcer. Within countries there are intra-national virtual water flows as well, again some of which from water-rich to water-poor parts of the country, but other flows move from water-poor to water-rich parts of the country (Dalin *et al.*, 2014; Zhuo *et al.*, 2016).

18.3 UNSUSTAINABLE GROUNDWATER USE IN RELATION TO TRADE

18.3.1 Global overview

In most countries, groundwater use has increased over the past decades, in both absolute and relative sense, although a stabilization has been observed in a few countries. According to Margat and Van der Gun (2013), groundwater abstraction in the US increased by 144% over the period 1950–1980 but stabilized afterwards. Wada *et al.* (2014) estimate that global groundwater withdrawals increased over the period 1979–2010 from 650 to 1200 billion m^3/y, an increase of 85%, while the ratio of global groundwater withdrawal to overall water withdrawals increased from 32.5% to 36.4% over the same period. During the period 1979–1990, global groundwater withdrawal increased by about 1% per year, but during the more recent period 1990–2010, groundwater withdrawals annually increased by about 3%. The growing importance of groundwater can possibly be explained as the result of increasing surface-water scarcity and the slowdown in the construction of new dams and reservoirs. Regional differences are large, as shown in Figure 18.2. In Europe, groundwater withdrawals account for about 30% of the total water withdrawal and has not increased substantially over the past decades. In North and Central America, however, groundwater withdrawal increased by more than 40% over the period 1979–2010, reaching about 60% of the total in 2010. In West Asia, groundwater withdrawal tripled, getting about 70% of the total in 2010. In South and East Asia, groundwater withdrawal nearly doubled over the period 1979–2010. In North Africa, groundwater withdrawal is about 30%. Over the other regions, like Southeast Asia and South America, groundwater withdrawals are less than 20% of the total.

Gleeson *et al.* (2012) estimate that groundwater withdrawals exceed groundwater availability – defined as groundwater recharges minus groundwater contributions to environmental stream flows – in 20% of the globe's aquifers. About 1.7 billion people live in these areas where abstractions exceed availability, where groundwater availability and/or groundwater-dependent surface water and ecosystems are thus at risk. The places with greatest levels of unsustainable groundwater use are: India, Pakistan, Saudi Arabia, Iran, Mexico, the USA, Northern Africa, China, and Central-Eastern Europe. In the Upper Ganges and Lower Indus Aquifers in India-Pakistan, the ratios of groundwater abstraction to availability average 54 and 18, respectively. In the North and South Arabian Aquifers in Saudi Arabia the ratios are 48 and 39, respectively, and in the Persian and South Caspian Aquifers in Iran the ratios are 20 and 98. In the Western and Central Mexico Aquifers the ratios are 27 and 9.1. In the High Plains and Central Valley Aquifers in the USA the ratios are 9.0 and 6.4. In the Nile Delta Aquifer in Egypt the ratio is 32, while the North Africa Aquifer shared by Algeria, Tunisia and Libya has a ratio of 2.6. In the North China Plain and Northern China

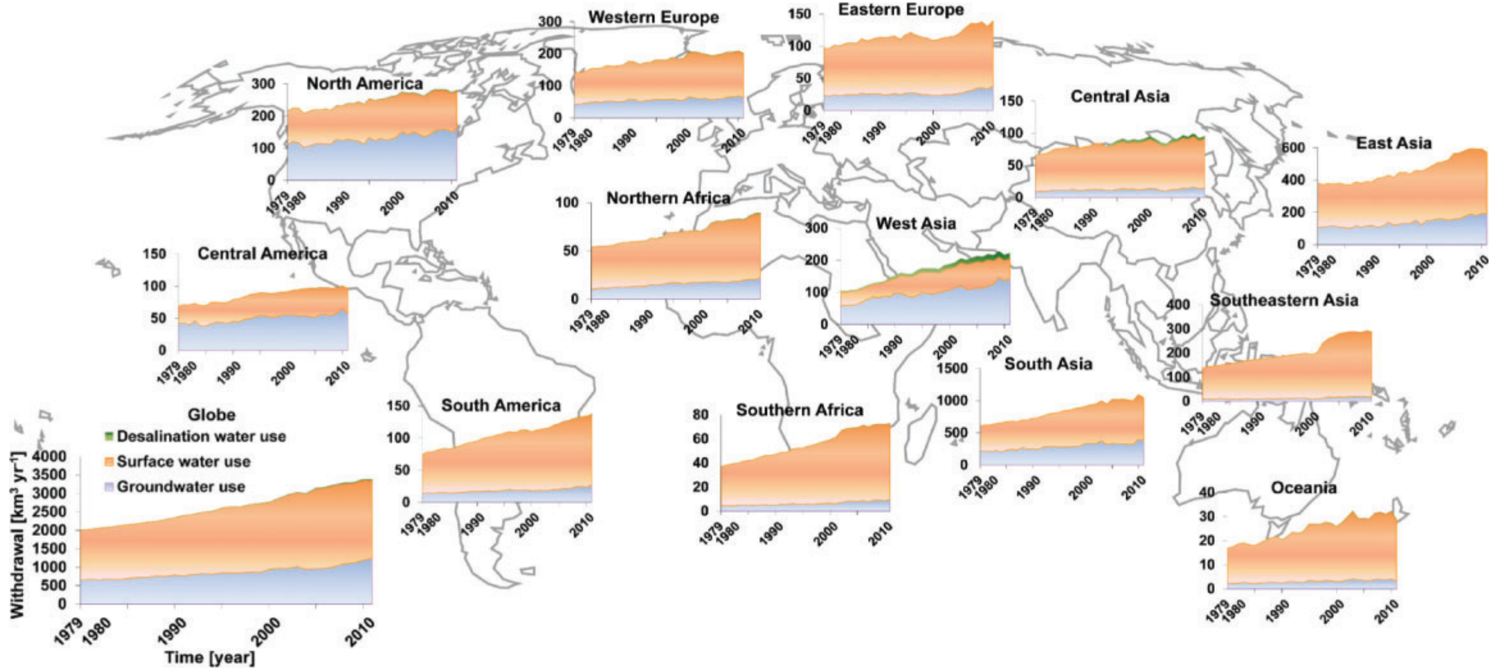

Figure 18.2 Regional trends of water withdrawal per source (groundwater, surface water and desalination water) over the period 1979–2010. The global figure is shown at the bottom left. Source: Wada *et al.* (2014).

Aquifers the ratios are 7.9 and 4.5. Finally, in the Danube Basin Aquifer below Hungary, Austria and Romania the ratio amounts to 7.4. In an earlier study, Wada *et al.* (2012) found that non-renewable groundwater abstractions constitute about 20% of the global gross irrigation water supply in the year 2000, with largest non-renewable groundwater abstractions for irrigation in India, Pakistan, the USA, Iran, China, Mexico and Saudi Arabia. They further found that globally, non-renewable groundwater abstractions more than tripled over the period 1960–2000.

As shown by Hoekstra and Mekonnen (2012), some of the countries with the greatest groundwater overexploitation are also among the greatest users of water for producing products for export: the USA, China, India, and Pakistan. India has been estimated to be the world's largest net virtual water exporter and the USA ranks third. Pakistan and China also rank high on the list of net virtual water exporters (seventh and eleventh, respectively). Even countries with net virtual water import, like Egypt and Iran, still have substantial virtual water exports.

Estimates of groundwater abstraction and recharge rates remain uncertain and vary across sources. According to Margat and Van der Gun (2013), the total global withdrawal of groundwater, estimated for the year 2010, is 982 billion m^3/y. They find that agriculture is responsible for 70% of the global withdrawal of groundwater, domestic water supply for 21% and industry for 9%. These estimates, adopted for example by FAO *et al.* (2016), are based on a compilation of national statistics. Wada *et al.* (2014) provides an overview of model-based estimates of global groundwater withdrawal, which range from 545 billion m^3/y (Siebert *et al.*, 2010; only considering groundwater use for irrigation) to about 1700 billion m^3/y (Wisser *et al.*, 2010). The weakness of statistics-based estimates is that they rely on scarce reported national statistics of unknown accuracy and reliability; the weakness of the model-based estimates is that they rely on various simplifying assumptions and uncertain input data. Presented groundwater abstraction data thus have to be taken with a large error margin. The same holds for groundwater renewal rates. According to FAO *et al.* (2016), the total global withdrawal of groundwater is equivalent to 8% of the mean global groundwater renewal. This global fraction obviously hides the large regional differences as shown by Gleeson *et al.* (2012) and Margat and Van der Gun (2013).

18.3.2 Overdraft of groundwater for producing export products

Worldwide, aquifers are being used and overexploited partly for producing export products. Dalin *et al.* (2017) estimate that about 11% of non-renewable groundwater is embedded in international crop trade, of which two thirds are exported by Pakistan, the United States and India alone. Unsustainable groundwater use for producing export products has most extensively been studied for the High Plains Aquifer in the Midwest of the US (Mekonnen and Hoekstra, 2010; Steward *et al.*, 2013; Esnault *et al.*, 2014; Williams and Al-Hmoud, 2015; Marston *et al.*, 2016). The High Plains Aquifer, also known as the Ogallala Aquifer, is a regional aquifer system located beneath the Great Plains in the United States in portions of the eight states of South Dakota, Nebraska, Wyoming, Colorado, Kansas, Oklahoma, New Mexico, and Texas. It covers an area of approximately 451,000 km^2, making it the largest area of irrigation-sustained cropland in the world (Peterson and Bernardo, 2003). Most of the aquifer underlies parts of three states: Nebraska has 65% of the aquifer's volume, Texas 12% and Kansas 10%

(Peck, 2007). About 27% of the irrigated land in the United States overlies this aquifer system, which supplies about 30% of the nation's groundwater used for irrigation (Dennehy, 2000). In 1995, the High Plains Aquifer contributed about 81% of the water supply in the High Plains area while the remainder was withdrawn from rivers and streams, most of it from the Platte River in Nebraska. Outside of the Platte River Valley, 92% of water used in the High Plains area is supplied by groundwater (Dennehy, 2000). Since the beginning of extensive irrigation using groundwater, the water level of the aquifer has dropped by 3 to 15 meters in most part of the aquifer (McGuire, 2007).

Major export products produced with water from the High Plains Aquifer include wheat, maize and cotton. Within the High Plains area, Kansas takes the largest share in wheat production (51%), followed by Texas and Nebraska (16% and 15% respectively). In Kansas, 84% of the wheat production comes from rain-fed areas. In Nebraska, this is 86% and in Texas 47%. The High Plains area accounts for about 14% of the total wheat production in the USA. Mekonnen and Hoekstra (2010) show that about 19% of the blue water footprint of wheat production in the USA lies in the High Plains area. They found a total blue water footprint of wheat production in the High Plains area of 1.1 billion m^3/y over the period 1996–2005. Texas takes the largest share (39%) in the blue water footprint of wheat production in the High Plains area, followed by Kansas (35%). There is a considerable variation in the blue water footprint per kilogram of wheat within the High Plains states, from 76 litre/kg in Kansas and 115 litre/kg in Nebraska to 304 litre/kg in Texas. Overall, the average blue water footprint per kilogram of wheat in the High Plains area is relatively large if compared to the average in the USA, which is 92 litre/kg.

In the period 1996–2005, the virtual water export related to export of wheat products from the USA was 57 billion m^3/y (Mekonnen and Hoekstra, 2010). About 98% of this virtual water export comes from domestic water resources and the remaining 2% is from re-export of imported virtual water related to import of wheat products. Taking the wheat consumption in the USA of about 88 kg/y per capita and a population in the High Plains area of 2.4 million, we find that only 2% of the wheat produced is consumed within the High Plains area and the surplus (98%) is exported out of the High Plains area to other areas in the USA or exported to other countries. This surplus of wheat constitutes 33% of the domestic wheat export from the USA. Figure 18.3 shows the major foreign destinations of wheat-related virtual water exports from the area of the High Plains Aquifer. Visualizing the hidden link between the wheat consumer elsewhere and the impact of wheat production on the depletion of water resources of the High Plains Aquifer is quite relevant in policy aimed at internalizing the negative externalities of wheat production and passing on those costs to consumers elsewhere.

18.3.3 Imported water risk

For importing countries it is increasingly important to understand their so-called 'imported water risk'. The water footprint of Jordanian consumption, for example, lies 86% outside its own territory and is largely located in the US, partially depending on unsustainable water supplies for wheat production and thus putting Jordan's food security at risk (Schyns *et al.*, 2015). Even countries that are relatively well endowed with freshwater resources may thus have a substantial imported water risk. About

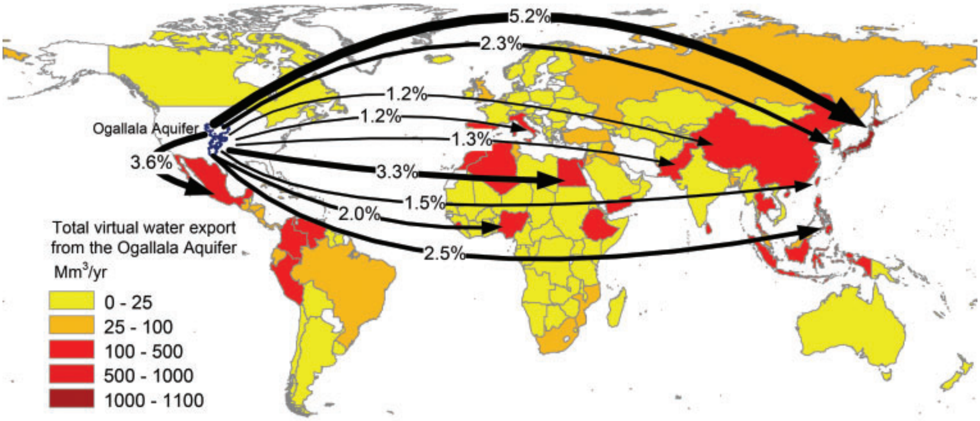

Figure 18.3 Major destinations of wheat-related virtual water exports from the area of the High Plains (Ogallala) Aquifer in the USA (1996–2005). About 58% of the total water footprint of wheat production in the area is for wheat consumption in the USA and 42% is for export to other nations. Only the largest exports (>1%) are shown. Source: Mekonnen and Hoekstra (2010).

75% of the total water footprint of UK consumption, for example, lies outside the UK and about half of UK's blue water footprint lies in areas where water use exceeds sustainable levels, for instance in Spain, the US, Pakistan, India, Iran and South Africa (Hoekstra and Mekonnen, 2016). This study for the UK shows the potential of establishing a relation between consumed products and underlying (remote) unsustainable water use, but tracing the water consumption and assessing the sustainability of that water consumption behind traded products remains a great challenge. There are relatively good data on international trade flows, but it's very difficult to estimate where precisely within an exporting country the export products have been produced. Besides, exports may be re-export of imported products as well, which requires further tracing. Another data challenge is still to distinguish the source of water being used in the places of origin, particularly to differentiate between surface water use and groundwater use. An increasing number of water footprint and virtual water trade studies explicitly differentiate between groundwater and surface water footprints (see for example Aldaya and Hoekstra, 2010; Dumont *et al.*, 2013), but this has to become standard practice.

18.4 THE IMPLICATIONS OF NATIONAL WATER ENDOWMENTS FOR INTERNATIONAL TRADE

There is an immense body of literature about international trade, but there are only few scholars who address the question to which extent international trade is influenced by regional differences in water availability or productivity. International trade is rather explained in terms of differences in labour productivities, availability of land, domestic subsidies to agriculture, import taxes, production surpluses and associated export subsidies, etcetera. According to international trade theory, which goes back to Ricardo

(1821), nations can gain from trade if they specialize in the production of goods and services for which they have a comparative advantage, while importing goods and services for which they have a comparative disadvantage. According to the Ricardian model of international trade, countries can best specialize in producing goods in which they have a relatively high productivity. In more precise, technical terms, economists say: countries have a comparative advantage in producing a particular good if they have a relatively high 'total factor productivity' for that good, whereby total factor productivity is a measure that relates output to all input factors (like labour, land, water). An alternative model of comparative advantage is the Heckscher-Ohlin model, which was formulated in the first half of the previous century. This model does not look at differences in factor productivity across countries, but at differences in factor abundance and in the factor intensity of goods. According to the Heckscher-Ohlin model, countries can best specialize in goods that use their relatively abundant factors relatively intensively. Neither model is comprehensive: whereas the Heckscher-Ohlin theory states that a country can best specialize in producing and exporting products that use the factors that are most abundant, Ricardo's theory says that a country can best focus on producing goods for which they have a relatively high productivity (output per input). But in any case, the rough idea is clear: production circumstances differ across countries, which gives some countries an opportunity in certain products, while it gives other countries an opportunity for other products, thus constituting mutual gains in trade. From the perspective of water, countries with either relative water abundance or relatively high water productivity (value of output per unit of water input), or a combination of both, will have a comparative advantage in producing and exporting commodities that are relatively water intensive.

An important question is what counts as 'water endowment' of a country. Groundwater resources are by far the most important freshwater resource in terms of stock (Gleeson *et al.*, 2016), but it would be a mistake to consider relative occurrence of water stocks across countries to estimate comparative water availabilities. Instead we have to consider freshwater renewal rates, i.e. the available flow of freshwater. The annual available freshwater flow is given by the precipitation over land, which splits up into usable green and blue water flows (evaporation and runoff). The blue water flow partly refers to direct surface runoff (precipitation directly going to small streams and rivers) and partly to indirect runoff (precipitation recharging groundwater and subsequently forming the base flow of rivers). Endowments in terms of groundwater flows and river water flows are both strongly related to the amount of rain. Hence, comparative advantages of countries in terms of water availability more or less follow relative rainfall rates. The advantage of groundwater is that it smooths out water availability within the year and between years, just like natural or artificial surface water reservoirs. For a measure of blue water availability, we have to consider the groundwater - surface water system as a whole, because groundwater and surface water resources are not additive. Groundwater recharge later forms the base flow of the river, so if we abstract water from the groundwater we cannot take it anymore from the river, and vice versa, if we want to take some base flow from the river, we shouldn't before already take it from the groundwater.

The relative abundance of green and blue water resources as a total – thus the rain as a total – and water productivity are the best measures of a region's relative comparative advantage in producing water-intensive commodities. The Midwest of the USA with its 400 to 600 mm of annual rainfall is thus not the place in the world most suitable for producing food for export, and the same holds for the North of China. The fact that those regions overexploit groundwater resources for producing export products shows the inadequacy of the global economy to take water scarcity properly into account, possible reasons being inadequate pricing and insufficient regulation. Although pricing and regulation can be implemented at national level, this isn't easily implemented because farmers living in countries that would apply more reasonable water pricing and protective regulations would be put in a disadvantageous position. Thus, implementing better pricing and regulation is politically difficult.

18.5 THE NEED FOR INTERNATIONAL COOPERATION IN GROUNDWATER GOVERNANCE

There is nothing more obvious than that overexploitation of aquifers can be regulated by setting a groundwater footprint cap for each aquifer, i.e. a maximum to the net water abstraction from an aquifer, and making sure that no more groundwater footprint permits are issued than available within the cap. These permits can be made tradable or issued based on some priority system or historical rights or whatever, but most important is to start with an agreement on a maximum abstraction rate. It is often assumed that the rate of groundwater withdrawal is "safe" or "sustainable" if it does not exceed the natural rate of recharge, but this is not correct (Alley *et al.*, 2002). The maximum sustainable level of the groundwater footprint on an aquifer depends on two variables: the groundwater recharge rate and which fraction of that can be sustainably withdrawn on annual basis without unacceptably affecting the base flow of the river that is fed with the groundwater outflow from the aquifer (Hoekstra *et al.*, 2011). What is unacceptable depends on the minimum flows to be maintained in the river system to preserve ecosystems and people that depend on this base flow. In practice this may imply that only 20–40% of the groundwater recharge rate is actually available for abstraction. Deep aquifers that are not or hardly recharged are not suitable for supplying water sustainably, so governments should be extremely careful in supplying abstraction permits in such cases. Even though it may take decades or centuries before aquifers get depleted, the risk of using them is that societies are built on a non-sustainable resource. The argument of possible substitution by another source in the long run generally doesn't hold, because the only reason to abstract fossil groundwater in the first place is that such alternative source is not available.

Agreeing on groundwater footprint caps for transboundary aquifers implies some form of international cooperation between the countries that share the aquifer. But probably another much larger form of international cooperation is needed to establish the whole idea of groundwater footprint caps. The reason is that setting such caps will influence the global food production pattern as a whole, with significant economic, social and political implications. Major aquifers with substantial importance in producing food for the global market are not slightly overcharged, but by factors of a few to fifty times the sustainable abstraction rate. Reducing those abstraction rates will inevitably reduce export from those production regions, and also have great consequences for the farmers involved. These consequences have to be mitigated, which will be easier, particularly in developing countries, when this is put in the context of international cooperation. When water and resultant food prices go up as a result of water use restrictions, there needs to be some international agreement to keep a level playing field.

A second incentive that governments could employ, together with institutionalizing groundwater footprint caps, is to introduce water pricing depending on local water scarcity. A differentiation between groundwater and surface water prices should be implemented where relevant. Prices will vary from catchment to catchment and vary within the year depending on water demand versus supply throughout the year. Pricing water based on its economic value was already agreed upon by the international community at the International Conference on Water and the Environment held in Dublin in 1992 (ICWE, 1992), but there has never been a serious follow-up. Earlier I have proposed that national governments start negotiations on an international Water Pricing Protocol as a way to jointly agree on a way forward (Hoekstra, 2011), because it is in the interest of everyone that our global food supply system is based on sustainable water use, but it is apparently difficult for individual countries to make substantial steps one-sided. An international agreement on water pricing should ensure that users pay the full cost of water use, including investment costs, operational and maintenance costs, a water scarcity rent and the cost of negative externalities of water use. Such an agreement would need to include all water-using sectors, including agriculture.

A very different form of international effort could be the introduction of sustainable water use criteria in existing environmental labels to products or a dedicated water label. This could be done by the public sector – for instance in Europe where environmental labelling of products is most advanced – or through private sector initiatives as well. Suppose that a brand like Coca Cola decides to avoid sugar in its drinks that is grown with unsustainable groundwater reserves or that brands like Unilever and Nestlé decide to apply such criterion across their whole product portfolio, this may drive change by itself and provide incentives to governments to respond – they will have to because such market changes affect local employment, economy and citizens. Finally, the international financial sector should agree on including sustainable water use criteria in investment decisions, comparable to taking into account the impact of investments on greenhouse gas emissions, which is increasingly done.

All of the above options for better groundwater governance – institutionalizing groundwater footprint caps and environmental base flow requirements, more sensible water pricing, incorporating water sustainability in environmental labels for products, applying sustainable water use criteria in investment decisions, and international collaboration in all these matters – face serious economic, social and political obstacles. However, business as usual will result in continued groundwater overexploitation rates. The problem that our global food economy is partly built on unsustainable water supplies can only temporarily be ignored.

18.6 CONCLUSION

Worldwide, aquifers are overexploited, partly in relation to international trade. The international trade system does not have any mechanism to reduce the problem. On the opposite, overexploitation remains attractive in the short term. Good governance of the world's groundwater resources requires shared rules on sustainable use. National governments need to agree keeping groundwater footprints below aquifer-specific maximum sustainable levels, and to issue limited groundwater footprint permits within these maximum levels. Further we need to move to a global economy that incorporates water scarcity in prices of water-based products. Consumers, companies and investors should prioritize products that are based on sustainable water use and avoid products that contribute to overexploitation of aquifers or rivers. This requires a greater transparency on how specific products relate to groundwater overexploitation.

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