



**ADB Working Paper Series**

**THE TRADE AND WATER NEXUS**

---

Alexandre Le Vernoy

No. 669  
February 2017

**Asian Development Bank Institute**

Alexandre Le Vernoy is an International Consultant at Groupe d'Economie Mondiale (GEM).

The views expressed in this paper are the views of the author and do not necessarily reflect the views or policies of ADBI, ADB, its Board of Directors, or the governments they represent. ADBI does not guarantee the accuracy of the data included in this paper and accepts no responsibility for any consequences of their use. Terminology used may not necessarily be consistent with ADB official terms.

Working papers are subject to formal revision and correction before they are finalized and considered published.

The Working Paper series is a continuation of the formerly named Discussion Paper series; the numbering of the papers continued without interruption or change. ADBI's working papers reflect initial ideas on a topic and are posted online for discussion. ADBI encourages readers to post their comments on the main page for each working paper (given in the citation below). Some working papers may develop into other forms of publication.

In this publication, "\$" refers to US dollars.

Suggested citation:

Le Vernoy, A. 2017. The Trade and Water Nexus. ADBI Working Paper 669. Tokyo: Asian Development Bank Institute. Available: <https://www.adb.org/publications/trade-and-water-nexus>

Please contact the authors for information about this paper.

Email: [a.le.vernoy@gmail.com](mailto:a.le.vernoy@gmail.com)

Asian Development Bank Institute  
Kasumigaseki Building, 8th Floor  
3-2-5 Kasumigaseki, Chiyoda-ku  
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500  
Fax: +81-3-3593-5571  
URL: [www.adbi.org](http://www.adbi.org)  
E-mail: [info@adbi.org](mailto:info@adbi.org)

© 2017 Asian Development Bank Institute

**Abstract**

Understanding the impact of international trade on the use of water resources provides a set of interesting ideas and concepts to further strengthen the global sustainable development agenda. This paper investigates and devises the direct and indirect links between international trade and water resources. It shows that with the right domestic policies and international trade system, trade in water-related services as well as the transfer of innovation and technologies can efficiently contribute to the goal of achieving access to water, sanitation, and hygiene (Sustainable Development Goal 6). Indirectly, international trade in goods also affects water usages. Through a discussion of the concept of virtual water, this paper illustrates how countries are relying on international trade to source products from abroad for domestic production that would otherwise put further strain on their water resources. With the right policies, data collection, and accounting methods in place, trade in goods may be a powerful tool to help alleviate the water crisis across countries and regions.

**JEL Classification:** F13, O13, Q25, Q55

## Contents

INTRODUCTION .....	1
1. THE SDGS PROVIDE A BETTER WATER AGENDA.....	3
2. DIRECT EFFECT: BRIDGING THE WATER SERVICES, INFRASTRUCTURE, AND TECHNOLOGY GAPS .....	6
2.1 Trade in Water Services: A Substantial Benefit Eclipsed by an Erroneous Perception .....	6
2.2 Technology and Innovation Transfers .....	9
2.3 Trade and Infrastructures .....	10
3. INDIRECT EFFECT: VIRTUAL WATER.....	11
3.1 Virtual Water: Can Trade in Goods be a Solution to Water Scarcity?.....	12
3.2 Measuring and Securing the Gains from Trade .....	14
CONCLUSION AND POLICY RECOMMENDATIONS.....	15
REFERENCES.....	17

## INTRODUCTION

At first sight, trade and water may appear to be disjoint subject matters. But closer examination reveals a stimulating and often overlooked set of intersecting opportunities that can be leveraged to address some of the most pressing development challenges the world is facing. The recently adopted framework of the Sustainable Development Goals (SDGs) recognizes the importance of such interlinkages and the integrated nature of the global goals. Understanding these nexuses is of critical importance for the tangible delivery of a robust sustainable development agenda. This paper will try to harness the most salient touch points between water and international trade. In so doing, it intends to illustrate under which conditions international trade, trade policies, and trade related institutions can effectively (but not solely) contribute to the resolution of the current and future water crisis.

By 2050, global demand for water will have risen by 55% and wastewater discharges of growing urban populations will have increased nitrogen effluents by 180% compared with today's rates, creating severe water stress that will affect about four billion people's livelihoods, (OECD 2012). It is under this scenario that the international community agreed on a specific water goal as part of the SDGs.

Water insecurity is rooted in four major concerns stretching from physical water scarcity (lack of availability of water aggravated by erratic climate patterns), declining water quality, weak management (and regulatory frameworks), to infrastructure gaps. The water crisis is affecting all dimensions of the use of this resource, whether for Water Access, Hygiene and Sanitation (WASH) purposes, or for agricultural and industrial purposes.

At a global level, it is expected that under a business-as-usual scenario, by 2030, the demand for water will outpace current supplies by 40% on average and by more than 50% in countries that are developing most rapidly (WRG 2009). Contributing to 70% of the world's water withdrawals, agriculture and farmers will suffer the most from the water crisis. At current growth rates, the coming decade is likely to witness a cereal production shortfall of 30% (WRG 2009). A recent World Bank report suggests that the effect of the crisis will have impact beyond agriculture to affect industrial capacities. In India, for instance, over the course of 2015, power plants suffered from long shutdowns due to decreasing levels of water in dams and reservoirs and due to erratic monsoon seasons. Overall, lack of water in all its forms could reduce the world's gross domestic product by 2.6% (World Bank 2016).

Global averages should not shift the attention away from varying local situations. Across all continents we now see the effect of shifting climate patterns impacting water availability in quality and quantity and in turn affecting economic activities in unprecedented ways (Jouanjean et al., Forthcoming 2016). Droughts and water shortages in South Africa, California, Australia, or southern parts of the People's Republic of China are examples showing that this is not just an issue for least-developed countries; the water crisis is affecting all continents irrespective of their level of wealth.

A related issue is the lack of access to water and the essential basic services it provides in terms of health and hygiene. The Millennium Development Goals (MDGs) already contained a WASH goal to draw attention to the considerable infrastructure-related efforts that were required to provide universal access to water. While substantial results were achieved in that respect over the past 2 decades, many countries are still significantly lagging particularly in Sub-Saharan Africa. A growing

demography and the rural–urban shift are powerful trends at play that justify the identification of new responses to the crisis.

Access to water is not just an obvious basic necessity. Accessing water in sufficient quantity and quality is also the basis for any country to lock in all the potential of its economic development. Technology, innovation, and hard infrastructure are the three pivotal components of a meaningful resolution to the water crisis. Investments in infrastructures and services provision will ensure the WASH goal is reached and all sectors of the economy can access reliable water. Strong management that articulates planning, distribution, and efficient use of water with consistent and adequate regulatory frameworks will ensure availability of the resource in time and space to the various productive usages. In situations of acute water stress, when water demand cannot be met, strong management practices and governance instruments represent the only guarantee that trade-offs will be weighted optimally.

Various concerns over water usages may be concomitant to international trade. These are not necessarily a root cause but rather a by-product of how countries decide to produce and trade. One of the most striking examples is the case of irrigated cotton production for exports by Uzbekistan that drove a severe and almost irreversible depletion of the Aral Sea. Kenya's exports of cut flowers are taking place at the expense of a drained Lake Naivasha (Hoekstra 2010). Through heavy subsidies Saudi Arabia has long been in the top ten of the largest exporters of wheat leading to the overuse of the country's fossil underground water. Recognizing the severe strain put on its groundwater resources, the Kingdom recently decided to phase out its heavily subsidized cereal production and rely on international food markets. As such, international trade can also be part of the solution to the lack of water acting as a mechanism to compensate for unsustainable water abstraction in water-scarce countries. For instance, in many Middle Eastern and North African countries, lack of water is a key driver for food imports without which food security would be impossible.

This paper argues that many solutions to the water challenge can be found in a more concerted openness to international flows of goods and services. A development-oriented trade regime coupled with suitable domestic policies may help counteract the impact of the water crisis and perhaps support its resolution in the medium term. Therefore, international trade can help achieve the water ambition of the SDGs.

This paper investigates the channels by which and the conditions under which international trade may contribute to tackling the water challenge. The first section of the paper shows the conceptual advances moving from the MDGs to the SDGs in addressing the water crisis and how this shapes a role for international trade and trade policy. To further reveal the interconnectedness between trade and water, the paper distinguishes between direct and indirect effects. The second section investigates the direct effect of trade, looking at how upgrading water management and infrastructures requires inputs in terms of goods, services, investment, and innovation, many of which can be sourced from abroad or facilitated at the multilateral level. The third section looks at an indirect but no less powerful effect of trade through the use of water as a production factor and the analysis of the concept of virtual water. The final section discusses potential policy implications necessary to unlock the win–win scenario of the trade and water nexus in a way that promotes the achievement of the SDGs' water goal.

## 1. THE SDGS PROVIDE A BETTER WATER AGENDA

At the time of the approval by the United Nations of the MDGs in 2000, many international agencies and organizations had already voiced their concerns about a water crisis rooted in a worsening gap between supply and demand for water as well as misaligned management practices. The MDGs did not provide much room for a wider approach that should have encompassed aspects beyond WASH and included water quality issues, management of wastewater, efficiency, and conservation of aquatic environments. In essence, the SDGs are now supporting the view that water is embracing many aspects of a strong development agenda. This section investigates the progress made conceptually moving from the MDGs to the SDGs and how the latter provide an improved framework to better leverage the interconnectedness between trade and water.

**Table 1: Mentions in Official Declarations—Counting Occurrences and Frequencies**

Words	SDGs Official Declaration of Adoption (1)		MDGs Official Declaration of Adoption (2)	
	Frequency	Occurrences	Frequency	Occurrences
<i>development</i>	11.2	170	8.1	28
<i>women/gender</i>	3.0	46	2.0	7
<i>environment(al)</i>	2.2	34	2.3	8
<i>health</i>	2.0	31	none	none
<b><i>(fresh)water</i></b>	<b>1.8</b>	<b>28</b>	<b>0.9</b>	<b>3</b>
<i>agriculture/land</i>	1.7	26	none	none
<i>poverty</i>	1.6	24	2.9	10
<i>hunger/food</i>	1.4	21	0.9	3
<i>(in)equality</i>	1.2	18	0.9	3
<i>peace(ful)</i>	1.2	18	4.9	17
<i>resilience/resilient</i>	1.2	18	none	none
<b><i>trade</i></b>	<b>1.1</b>	<b>17</b>	<b>0.6</b>	<b>2</b>
<i>energy</i>	1.1	16	none	none
<i>private sector/sphere</i>	1.1	16	0.6	2
<i>inclusive/economic growth</i>	0.9	14	none	none
<i>ecosystem</i>	0.8	12	none	none
<i>WTO/World Trade Org.</i>	0.5	7	none	none

SDGs = Sustainable Development Goals; MDGs = Millennium Development Goals.

Source: Count by the Author; frequency denotes numbers of occurrences per 1,000 words.

(1) From Outcome document of the United Nations summit for the adoption of the post-2015 development agenda.

(2) From Resolution adopted by the General Assembly toward the MDGs declaration.

Trade has received more attention in the discussion that led to the agreement on the SDGs than was the case for the MDGs. As the messaging in official documents is so carefully weighted and scrutinized before their adoption, it is interesting to look at how words have been used to build each agreement. The following table compares the number of occurrences and the frequency (i.e., number of occurrences per 1,000 words) across a set of keywords that are presumably important for appreciating

the focus of sustainable development discussions. The comparison is done by scanning through two significant milestones—the Resolution adopted by the General Assembly of the United Nations consecrating the MDGs, on the one hand, and the Outcome document of the United Nations summit for the adoption of the post-2015 development agenda (adopted by the General Assembly of the United Nations), on the other.

The designers of the SDGs have put more emphasis on water and trade compared with the MDGs. The words “(fresh)water” and “trade” are significantly more frequently used in the SDGs. Interestingly, the term “private sector” is also more widely used, perhaps because of the current appreciation of its role in supporting the development agenda. It is also important to note that World Trade Organization (WTO) and “ecosystem” are now mentioned in the SDGs. Looking at the two documents in more detail, it is important to note that the SDGs allow for a more complex approach on the grounds that most of the issues are interconnected and cannot be approached in isolation. SDG 6 defines the water target for the 2030 agenda as follows: “Ensure availability and sustainable management of water and sanitation for all”:

**6.1** Achieve universal and equitable access to safe and affordable drinking water for all.

**6.2** Achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.

**6.3** Improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated waste water, and increasing recycling and safe reuse globally.

**6.4** Substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity.

**6.5** by 2030 implement integrated water resources management at all levels, including through trans boundary cooperation as appropriate.

**6.6** by 2020 protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.”

There are other areas and goals that explicitly mention water and water security as a means to the achievements of the agenda, providing interesting touch points across all the goals. These touch points are:

Goal 3. “Ensure healthy lives and promote well-being for all:

3.3: By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.”

Goal 11 “Make cities inclusive, safe, resilient and sustainable:

11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.”



Goal 12 “Ensure sustainable consumption and production patterns:

12.4: By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.”

Goal 15 “Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss:

15.1: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.”

The capacity to ensure reliable access to water in sufficient quantity and quality has major impacts on several aspects of economic development such as health, energy, ecosystems protection, stable agricultural production, and food security. The capacity of resilience of all these systems is also correlated with the capacity of access to the resource in case of sudden, short, or longer shocks. As shifting precipitations and temperatures affect cropping patterns and hence agricultural production, or as sudden adverse weather affects infrastructure, climate shocks will threaten the speed at which populations and economic activities can recover. This stresses the need for stimulating synergies across several goals. Most of the concepts referenced in the goals about freshwater management have been around for more than 2 decades (Integrated Water Resources Management, water pricing, and ecosystems and their services). But their practical application and implementation have been hampered locally by lack of adequate and mature regulatory frameworks.<sup>1</sup> Hence, without more clarity about how to translate these goals into specifically designed domestic policies and targets, it is difficult to project the outcome of the goals on resolving the water crisis. At this stage, it remains interesting to see how existing tools and institutional structures can help address the water crisis in general and achieve the water goal in particular.

Modern responses to water scarcity involve a balance between adopting hard and soft strategies. Hard approaches refer to infrastructures, maintenance and operations, traditional water storage systems, storage management, water reuse, desalinization, or integrated flood management. At the other end of the water strategies spectrum we find soft interventions aimed at curbing inefficient uses or establishing proper institutional frameworks. They focus on demand-oriented approaches and use instruments such as pricing mechanisms, efficient technologies, establishing a culture of conservation, land use planning, or education and communications.

Another soft strategy often mentioned is the relationship between water and international trade. It is recognized that international trade holds a promise for water savings and the reallocation of water to higher-value alternative usages and production processes. Materialized by the concept of virtual water described below, the concept allows for an interesting compromise to align both demand-based and supply-based approaches into a single vision. Combined with appropriate domestic policies, trade in agricultural products may contribute to reducing imbalances between countries using water more or less efficiently.

---

<sup>1</sup> The concept of integrated water resource management was put forward as early as 1992 and included in the Dublin principles following the Rio commitments.

SDG 6 certainly recognizes one of the most pressing issues surrounding the current water challenge, which is the lack of access to WASH currently affecting about 2.5 billion people. The SDGs have lacked ambition in that they fail to clearly identify water as one of the key issues for prosperity. Of course, access is the most pressing challenge that needs to be tackled, but it would have been potentially beneficial to put it in a more complex perspective of the manifold interconnections the water issues have with other challenges such as long-term sustainable agriculture, and energy security, all of which cannot be effectively tackled in isolation. While it remains a second-best instrument, we argue that trade can be a powerful instrument to tackle the water crisis.

Further below we look at the direct and indirect contributions of international trade to these two dimensions of water management responses. The literature relating to the water crisis suggests rather unambiguously that water is a local issue that has regional and global ramifications particularly through the impact of globalization on the interconnectedness of the world economy (Hoekstra 2010). In a context of climatic disruptions, trade may act in the medium term as the insurer of last resort. It also emphasises the idea that the trade and water communities of experts and decisions makers share common ground. Seeking an aligned agenda between the two communities could provide powerful support for an ambitious and practical implementation of the SDGs. Critically, the misunderstanding that has led the debates over the past decades (particularly on the topic of privatisation of water, described below) could have detrimental effects on securing the achievement of the SDGs. Through applying the right concepts and instruments, and through appropriate policy implementation, there is a clear win-win case for delivery on the SDGs.

## **2. DIRECT EFFECT: BRIDGING THE WATER SERVICES, INFRASTRUCTURE, AND TECHNOLOGY GAPS**

Ensuring a consistent response to the water challenge is dependent on the capacity to attract new investments and secure the provision of services (distribution and treatment of water). Parallel to this, the difficulty of maintaining or replacing aging water-related infrastructures has been widely documented (OECD 2011). The security of access to water can only be meaningfully achieved through the development of significant funding capacities for infrastructure projects on drainage, treatment (of both raw water and wastewater), distribution, abstraction, and storage. All those areas are critical to achieving SDG 6. This section suggests some ways to think about international trade as a conduit to directly redress part of the current gap in the provision of water technologies, services, and investments.

### **2.1 Trade in Water Services: A Substantial Benefit Eclipsed by an Erroneous Perception**

The market for environmental goods and services (EG&S) has grown rapidly over the past decade and is expected to reach \$1.9 trillion by 2020 (Bucher et al. 2014). As defined by the Organisation for Economic Co-operation and Development (OECD), EG&S refers to productive activities as those “that produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air, soil, as well as problems related to waste, noise and eco-systems.” Following this definition but appreciating that not all countries are able to access the same levels of technology, the uneven technological capacities across countries creates a positive role for international trade to allow for the diffusion of these goods and services through

several channels—transfer of technologies, direct investment of companies holding patents, or direct export of the goods or services.

Although gaps are still wide across countries, with developing countries still catching up, environmental regulations have evolved significantly in recent years. As far as water use and treatment is concerned, national standards have on the whole become more stringent and have been supported by a wave of revisions of domestic water laws. The water sector is still largely concentrated, with just a few multinationals operating in the sector, for two main reasons: First, these multinationals have the capacity and the reach to beat the market and historical operators are difficult to challenge from a cost perspective. Second, municipalities and other users of water-related services continue to put more trust in historical operators to implement technologies and processes that comply with increasingly complex water-related regulations. But the landscape is likely to change. Developed countries are more mature in implementing environmental regulations and growth in this sector is expected to shift to developing countries, with some of them already developing their own sector (South Africa and Taipei, China being salient examples). Moreover, with regulation on water distribution, treatment, and collection evolving rapidly, the industry is becoming more responsive to breakthrough technologies, which makes the sector more competitive. As water management is extremely dependent on local contexts, we expect it will facilitate the creation of small domestic businesses more capable of reacting and responding to local contexts (WTO 1998).

A reduction in trade barriers and the promotion of flows of services in the water sector could help support the transition to a more stringent regulatory framework that fosters the preservation of water resources and ecosystems by providing efficient solutions at lower costs.

There has been strong opposition to the incursion of the private sector into the delivery of water services. The upsurge in privatisation of water-related services in several developing countries has fuelled a heated controversy over the past 2 decades. Central to the debate over the modalities of management of the resource is the symbolism attached to water—inherited from representations, traditions, and cultures—and the possible social implications of adaptation to a new management model. Such resistance should not be taken lightly and recent experiences of privatization show it reflects legitimate concerns. Customs, cultural practices, and even myths can explain a variety of management practices of water resources, which often clashes with the utilitarian views advocated by modern management approaches (McCool et al. 2008). While water pricing is expected to correct the lack of signal of scarcity, this solution is often viewed as a narrow and doctrinaire approach that shakes the foundation of the representation of the value of water.

Defining the institutional framework for the provision of water services has been difficult, with the debate dichotomy-driven so far between those advocating private provision of water services and those advocating public provision. In light of this, it is important to remember some of the basic principles behind the General Trade Agreement on Services (GATS). The literature generally expects liberalization of services to generate the following benefits (Bates 2009): consumer savings by way of reducing trade barriers; greater transparency and predictability through an agreed set of rules, and long-term investment—all of which are better discussed and settled multilaterally.

The agreement on services does not provide any guidance or principle as to whether the provision of water services (or any other services) should be owned and managed by public or private entities. Ex ante, there is nothing in the general rules and principles (contained in the agreement) that forces a country to privatize water related services (ODI 2005). As such, the GATS under the auspices of the WTO says nothing about how water provision should be handled by WTO members countries.

The agreement adopts a positive approach whereby signatories to the GATS schedule their commitments in a list of choices. Countries' commitments do not apply unless the sectors and their corresponding sub-sectors are expressly inscribed in the schedule. To date, commitments to liberalize water services and related sectors under the GATS have been rare. One explanation is linked to the sensitivity of this issue, but it may also be due to the complexity of the classification for water. The only water sector clearly referenced is Sewage services found in the category of Environmental services. Commitments on other water related services thus should be scheduled under a different and generic category such as construction and related services or distribution services.<sup>2</sup> A better definition of the classification (which is part of an ongoing discussion) could certainly bring some clarity to further negotiate liberalization in this sector.

Trade in water-related services, unfortunately, is driven by many erroneous perceptions that may have eclipsed the potential of important benefits for countries of the trade agreement in facilitating both investment and the provision of high value services from abroad. The opportunity cost may come at a high price point for countries that lack the capacities to implement efficient services themselves. GATS negotiations are still hindered following the deadlock of the Doha Round of negotiations. A coalition of the willing comprising 23 WTO members (including the European Union) recently decided to move forward in the area of trade in services. It is still unclear how the Trade in Services Agreement (TiSA) might deal specifically with water. The communication lesson has been learned and the coalition took time to defuse expectations about public services in general and water in particular.<sup>3</sup> It will be interesting to see if the coalition manages to provide some clarity in the debate on the liberalization of key "public" services and particularly around water.

At present, it looks unlikely that we will see major unilateral, regional, or multilateral GATS commitments on water services. Yet, alongside South Africa, several national governments that had expressed their reluctance to schedule commitments for water services under the GATS have nevertheless started to liberalize their services (outside the multilateral framework of negotiation), as they recognize the pivotal role of the private sector in ensuring adequate and efficient water management. This position is also a strong echo of the simplistic treatment of water-related services in the current multilateral trade system that fails to address the specificities of ensuring access for the poorest (Muller 2003). This consensual opposition to strong GATS commitments on water-related services is unfortunate insofar as it hampers and delays the mutual benefits that international trade coupled with efficient domestic regulations could bring about to resolve the water crisis.

---

<sup>2</sup> I-TIP Services is a joint initiative of the World Trade Organization and the World Bank.

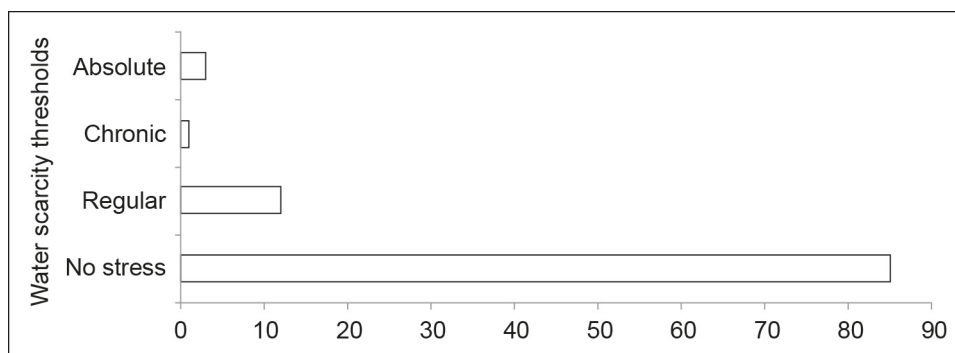
<sup>3</sup> The European Commission website has a dedicated page to address frequently asked questions about the TiSA. <http://ec.europa.eu/trade/policy/in-focus/tisa/questions-and-answers/> (accessed 15 February 2017).

## 2.2 Technology and Innovation Transfers

An efficient framework to support a wider diffusion of water technologies remains crucial to addressing the water crisis. Even with improved infrastructures, the diffusion of innovations and technologies constitutes a powerful supply-side approach to the lack of access to water and the preservation of the resource. Added to the fact that intellectual property rights are not well enforced and secured, private companies holding patents will continue to prefer investing themselves rather than licensing their technology, narrowing down the channels through which technology can be diffused and adopted.

International technology transfers can in principle also positively impact the demand side by ensuring that agricultural, industrial, or domestic water users are granted access to non-R&D innovative processes and instruments focusing on more efficient usages of water resources. A novel study by Conway et al. (2015) using patent disclosure data, suggests that most supply-oriented inventions tend to originate in countries where water availability is relatively high (the results are reproduced in Figure 1).

**Figure 1: Water Scarcity and Share of World's Water-related Inventions, 2000–2010 (%)**



Source: Reproduced from Conway et al. 2015. Threshold of water stress is defined following Falkenmark's (1995) methodology.

Having these inventions and innovations developed in countries where they are less needed justifies such a global diffusion. With environmental regulations adequately enforced and monitored, the reduction of trade barriers and constraints on foreign direct investment, leading to a more open international trade environment, should promote the diffusion of these technologies and inventions. Some countries have demonstrated that this is possible. The role of knowledge centers is critical as well and momentum exists as we witness a rapid growth in the water-related R&D sector. Alongside matured actors in water-efficiency technologies in several developed countries, Singapore is a singular and compelling case example described by Speight (2015). Water treatment processes in Singapore were an apparent competitive disadvantage but also an obvious need. Through its efforts in specialization, Singapore has significantly reduced its dependence on water imported from Malaysia through investing in desalination technologies and now serves as a global R&D hub in the water sector acting as a hub for Asia and the rest of the world. Large multinational companies are now investing in Singapore to support the development of the research in the field of water technologies.

The literature usually distinguishes four main channels for effective international technology transfers: foreign direct investment, movement of people, trade in goods, and knowledge spillovers (Hoekman et al. 2004). The existence of regional knowledge and research hubs on water also calls for a stronger role for international trade that could promote North–South as well as South–South international technology transfers. Also important to note is the role of ex ante local capacity to effectively absorb the innovation for international diffusion to be a success. Lack of training and technical assistance is frequently a cause of failure throughout the process of acquisition and implementation by local authorities. Cases of transfers of waste and water treatment technologies have been well documented (Tébar Less and McMillan 2005) and demonstrate yet again the importance of local and domestic capacity building for local officials to ensure diffusion.

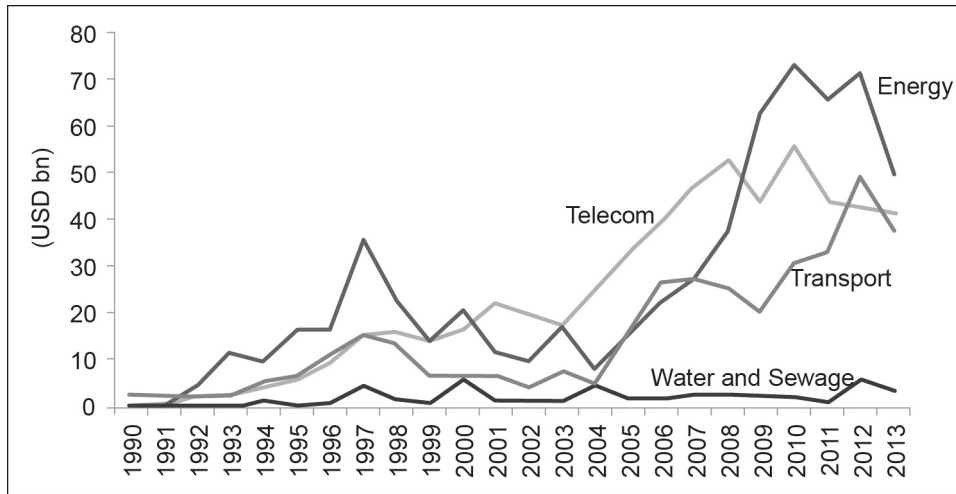
### **2.3 Trade and Infrastructures**

Reliable infrastructures are essential for international trade and global integration. What is true for transport and energy infrastructures is also true for water as a basic and significant input for most economic activities and ultimately for the production of goods that are exported and imported. Ensuring the right level of investment in water-related infrastructures thus becomes a precondition for reaching SDG 6. And the trade and investment nexus has a role to play in stepping up the development of infrastructure in water as well as in other areas and to strengthen a county's competitiveness while achieving poverty reduction.

Demand for investment in the water sector is expected to increase rapidly, creating a predictable gap between the current funding capacities and the obvious capital and operational requirements for new infrastructure. Globally, \$11.7 trillion of investments have been made in water facilities and other forms of water related infrastructure to support the projected growth toward 2030 (McKinsey 2013).

As mentioned above, there are several channels through which the water crisis can be alleviated, but technology and hard infrastructures will remain pivotal for ensuring equitable and sustainable access to water. Investments in water works are largely the prerogative of the public sector given their capital-intensive public good nature and because they require important early investments that have generally low rates of return with extended payback times. The private sector is being granted an increasingly important role in the provision of water services and infrastructure. Yet, compared to the energy, communication, or transport sectors, the water sector is undermined by a lack of enthusiasm from the private sector. Data from The Private Participation in Infrastructure Database developed by the World Bank shows that the water sector has suffered from chronic underinvestment by the private sector. Major trends are reported in Figure 2.

And the lack of investment is also more apparent in regions where it is needed the most, such as in countries of Sub-Saharan Africa where, incidentally, progress toward realizing the MDGs has been limited. While in the private sector the notion of water risk is increasingly being integrated into business strategies, it does not seem to stimulate enough investment despite a worsening of the water crisis. In light of this context, official development assistance should consistently focus on strategies to support infrastructure development in developing countries generally and water infrastructures in particular. Above all, development partners should ensure a sound investment climate for the private sector.

**Figure 2: Private Investment Commitments in Infrastructure (1990–2013)**

USD = United States dollar.

Source: Based on data downloaded from World Bank and PPIAF, PPI Project Database. <http://ppi.worldbank.org> (accessed 15 February 2017).

Several policy choices could be adopted to foster investments, but most important would be a consistent multilateral regime to aggregate disparate domestic investment policies. The OECD recognizes that even though water infrastructures are not a trade-related infrastructure category per se, water for irrigation and sanitation for meeting sanitary and phytosanitary standards (SPS) do in fact “contribute to productivity and the ability to compete.” Water availability in sufficient quantity and quality is an essential parameter for food safety and to safeguard exporting capacities and compliance with international SPS (e.g., GlobalGAP). In line with this, the Aid for Trade agenda could make a significant contribution to addressing the quality side of the water challenge by ensuring that investments (and official aid) support the fulfilment of requirements around SPS and technical barriers to trade requirements.

### 3. INDIRECT EFFECT: VIRTUAL WATER

As pointed out in the previous section of this paper, significant differences across countries in both availability and access to water technologies can explain the struggle to preserve existing water resource or efficiently mobilize untapped resources. In much the same way, we witness varying levels of technologies in the agricultural sector across countries along with sharp differences in labour productivities as well as land availability. These aspects are considered to be some of the main driving forces behind the pattern of international trade in agriculture. As water is a crucial input for agriculture, an additional question, therefore, is whether relative international differences in water availability also contribute to shaping the patterns of international trade flows?

Cross-border transfers of bulk water are politically sensitive and the integration of water as a commodity in trade agreements leads to delicate negotiations among states over the ownership and sharing of the resource. During the negotiations to conclude the North American Free Trade Agreement (NAFTA), Canada forced the inclusion of a clause in the regional trade agreement to “protect” its freshwater from exports. Recently, an American water export company launched a lawsuit against Canada for \$10.5 billion and the case has been filed under Chapter 11 of NAFTA. But water is

hardly ever traded as such. Notable examples of cross-country water transfers are projects between the south of France and the autonomous region of Catalonia in Spain, and between South Africa and Lesotho. Most large-scale transfers still occur domestically. The People's Republic of China is just finalizing the largest networks of pipelines in history to transfer water from the north to the south of the country, at a total length of 4,350 kilometers. Large-scale water transfers commonly attract attention from the media and scrutiny from the civil society, particularly concerning their environmental and social implications.

Through the Harmonized Systems, customs classify bulk water explicitly as “Ice, snow and potable water not sweetened or flavoured.”<sup>4</sup> Imports of bulk water reported to the United Nations statistical agency amounted to an annual average of 0.34 km<sup>3</sup> between 2011 and 2015, an insignificant volume compared with the annual global average withdrawal of 3,908 km<sup>3</sup> over the same period.<sup>5</sup>

However, water is being transported by other means. It can flow between trade partners through imports and exports of products when it is accounted for as a production factor in products. Virtual water is the volume of water used (and embedded) in the production of a good or a service (Allan 1997). Each production process requires very dissimilar amounts of water, which may vary from country to country. While products are traded regionally or globally, movements of goods involve virtual transfers from one trading partner to another of the water used in their respective production process. This water is said to be virtual because it is not present as such in the product, but was required for its production.

From a pure trade economics perspective, the theory of comparative advantage revolves around the idea of trade in factor services—also referred to in the literature as the factor content of trade. The theory shows how trade takes place among countries based on how much of a relative factor is used in the production of goods and depending on the relative cross-country differences in endowments of the inputs used in production. This section summarizes the debate so far about the concept of virtual water and suggests some aspects of its applicability and implementation from a trade policy perspective.

### **3.1 Virtual Water: Can Trade in Goods be a Solution to Water Scarcity?**

A methodology to calculate the water content of trade or virtual water flows associated with trade in crops and livestock was developed through the evaluation of a product- and country-specific water requirement coefficient (usually measured in cubic meter of water per ton of product). Pre-multiplying this coefficient by the trade flow of the corresponding product allows for the quantification and the mapping of volumes of virtual water between trading partners. It gives interesting insights into the water content of trade flows across the world. The key importers and exporters of net virtual water flows are ranked in Table 2.

---

<sup>4</sup> The exact HS code is 22-01. Chapter 22 includes all beverages, spirits, and vinegar whether they are bottled or not but does not cover (i) products of this chapter (other than those of heading 2209) prepared for culinary purposes and thereby rendered unsuitable for consumption as beverages (generally heading 2103); (ii) sea water (heading 2501); (iii) distilled or conductivity water or water of similar purity (heading 2853).

<sup>5</sup> World Development Indicator database, The World Bank.



**Table 2: Top 10 Net Virtual Water Exporters and Importers**  
(km<sup>3</sup>)

Rank	Net Virtual Water Exports km <sup>3</sup> in 2005		Pressure on Water Resources (%)	Net Virtual Water Imports km <sup>3</sup> in 2005		Pressure on Water Resources (%)
1	Australia	64	3	Japan	92	19
2	Canada	60	1	Italy	51	28
3	US	53	14	UK	47	6
4	Argentina	45	4	Germany	35	21
5	Brazil	45	1	Rep. of Korea	32	42
6	Côte d'Ivoire	33	2*	Mexico	29	17
7	Thailand	28	13*	Iran	15	68
8	India	25	34	Spain	14	33
9	Ghana	18	2*	Saudi Arabia	13	943*
10	Ukraine	17	8	Algeria	12	67

US = United States; UK = United Kingdom.

Note: In this table \* denotes data for 2006.

Source: Data on virtual water flows are from the Water Footprint Network and Hoekstra et al. 2003. Data on pressure on water resources express freshwater withdrawal as % of total renewable water resources and are extracted from The UN FAO Aquastat database.

Some of these results may be at odds with the conventional perception of the state of the resource. How can two parched countries like Australia and India be major exporters of virtual water?

Australia's freshwater withdrawals represent just 3% of its total renewable water resources. This country-level average hides local differences across States and Territories. The Murray–Darling basin's economic activities are underpinned by significant farming activities that use irrigation as the main mode of production adding up to the use of 80% of the basin's available water, while contributing to 5% of the gross domestic product of the area. Although it represents a small fraction of the basin's economy, water shortages could come at a high price for the continued growth of the country. The South West of the country is also constrained by reduced rainfall supplies; a dynamic that is already affecting wheat production. It is worth noting that according to the Australian government, 80% of the wheat produced in that region is exported. One of Australia's main trading partners of wheat is Japan; a country that given its size, geography, and hydrogeology, is crucially lacking both land and water and relies on virtual water to ensure its food sufficiency. The water crisis in several regions of Australia has urged its government to implement a profound revision of its water management to ensure a better and more sustainable use of its water and redirect its use to higher-value usages. This does not necessarily exclude that agricultural production should be exported, as international of trade in agriculture represents a significant share of Australia's economic stability. In other words, even if there is a perceived disconnection between the size of a country's trade and its water availability, a solution to the challenge this represents can often be found in domestic regulations on access and use of water.

Water scarcity is rarely signalled through price. Because water is commonly mispriced, surface and groundwater are perceived as inexpensive sources of water supply. The reality is that water resources generally have a sharp marginal cost curve. As conventional water sources become scarcer, investment in unconventional supplies (desalinated water, reclaimed water, rain water harvesting) can find new market development, but this is not sufficient to tackle the issue in the medium term. For the more conventional provision of water, pricing policies are lacking and existing ones usually do not reflect the level of scarcity. Without efficient domestic regulations to ensure the right level of production and the allocation of water to high-value use (whether the output is for the domestic market or the international market) the water crisis can only worsen. In short, the solution is not to limit trade in agriculture but to ensure that water management strategies are in place that correctly reflect the property rights and the common good problem of the use of water.

### 3.2 Measuring and Securing the Gains from Trade

Can trade reduce imbalances between relatively water stressed countries and relatively water abundant countries? The concept of virtual water enables us to shed light on this. The concept seemed novel when first coined, but it should be conceptually familiar to trade economists as it can be seen as an application of theories of comparative advantage and factor content of trade (Le Vernoy and Messerlin 2011).

Using the data on the water content of world trade, gross virtual water flows amount on average to 1,624 km<sup>3</sup>, with 61% of the total virtual water trade associated with international trade in crops, 17% with livestock, and 22% with industrial products (Hoekstra 2010). Water may be saved through trade provided it moves from high water productivity countries to low water productivity countries. Savings do not amount to the volume of virtual water of the imported product but to the volume of water the importers would have required to produce the same quantity of product. Globally, savings represent on average 10% of global freshwater withdrawals (around 352 km<sup>3</sup> according to Chapagain et al. 2005). Given that gross flows of virtual water are for the most part explained by agricultural exports (as opposed to industrial trade) and that the current trade regime is heavily subsidized, this figure is in fact quite high. As imperfect as they are, the current trade rules are allowing for quite a substantial saving of water globally. At least, this figure gives a sense of what would be the cost of autarchy or, alternatively, the amount of untapped opportunities that lies in further trade integration (Le Vernoy and Messerlin 2011).

Trade becomes an alternative to the costly transportation of a rather internationally immobile and hardly substitutable production factor. The calculation of the volume of freshwater being saved as a by-product of international trade does not say much about the drivers or causality of such a relationship. An important question is whether the relationship can partly be traced to relative water scarcity across nations (as noted above in the case of India and Australia). On this issue the literature provides mixed results (Wichelns 2015). A study by Debaere (2014) based on recent data estimates relative water endowments across countries as a source of comparative advantage (in a Heckscher–Ohlin setting). The results suggest “that relatively water abundant countries export more water intensive products” but that the water content of trade is less significant in explaining trade patterns than capital or relative labor endowments.

The literature singles out three major “noises” in the estimation of the potential gains from trade for a more efficient global allocation of water to productive uses, that impede perfectly capturing the impact of trade. They relate to lack of information about the resource, incorrect water pricing mechanism signals, and agricultural subsidies. Such

elements can be addressed through concerted and consistent regional or global trade policies and domestic policies.

The overall amount of water available globally as well as the theoretical dynamics underpinning the water cycle have been established. Far less is known about local hydrological dynamics, particularly the state of groundwater resources. Catchment-based surveys often rely on outdated data. Furthermore, little is known about the dynamics of demand and the extraction rate of water resources. The trend is advancing towards more monitoring rather than less, but local and national regulations are more often than not based on incomplete information. More efforts in that area would be welcome to ensure that SDG 6 is achieved.

As noted above, water is too often mispriced and accounts for an insignificant share of production cost, rarely reflecting the value of scarcity and the cost recovery of the investments made to secure its availability. Moreover, if scarcity or decreasing quality issues are not correctly reflected in prices, it may leave the terms of trade generally unaffected by a relative difference in water endowments, hence distorting the positive impact trade can have on a “sustainable” and “efficient” relative allocation of water uses. Natural resource pricing is typically a domestic policy prerogative, which reinforces the notion that the benefits of more open trade can only be achieved with a relevant set of domestic policies.

Agriculture is a sector that has historically been subsidized. And the international trade system under the WTO recognized the need to support farmers and agricultural activity through direct support from the government, through measures that should only have minimal impact on trade in areas such as research, disease control, infrastructure, and food security, and direct payments for environmental assistance programs. There are examples of subsidies that distort the signal of water scarcity to the point that unsustainable use of water is being ultimately maintained rather than curbed (Boulanger 2007). On the other hand, we can assume that preserving some financial protection level of farmers can be important to ensure that sustainable water use is being achieved and which may require public investments and targeted regulations. But those instruments ought to be carefully assessed.

Following recent climate shocks and their impact on food production, countries are turning to food security policies to protect farmers and the agricultural sector from world price volatility. While it is understandable that countries want to reduce their exposure to world price volatility, this may come at an even higher price if it goes against sustainable water management. In this context, international trade should be considered as a powerful instrument in the medium term, to be used as an insurance mechanism against climate shocks. The benefit of a more open international trade environment can only be safeguarded through stable and reactive domestic policy responses to protect domestic economies from adverse social implications and negative environmental externalities.

## **CONCLUSION AND POLICY RECOMMENDATIONS**

With the current fragility of the WTO negotiations process attracting most of the attention, commentators tend to overlook the importance of the rules themselves. The negotiations on the reduction of trade barriers have recently lost momentum, but the trade regime and its underlying principles are remarkably lean and efficient. While perfectible, they provide the framework for a vast set of policy options to harness the benefits of international trade.

Water challenges respond to local issues and confined circumstances requiring institutional responses at the catchment level. Taking a closer look at the trade and water nexus reveals the emergence of a global water agenda with global concerns as well as global solutions and instruments. As the world only recently forged an ambitious climate agenda following the agreement at the 2015 Paris Climate Conference (COP21) and a development ambition through the SDGs, a stronger water regime has yet to materialize and is unlikely to develop quickly. This paper argues that until a water regime develops, the current trade regime can be put to good use to address (partly) some of the most pressing water challenges.

The potential adverse effects on water resources of untenable productive activities, some of which have been recalled in the introduction of this paper, cannot be dismissed. In these cases, international trade cannot be seen as the root cause of the unsustainable use of water. Mismanagement of the resource and short-sighted choices are at the core of the water crisis. In so far, this paper looked at both direct and indirect linkages between international trade and water.

In a growing number of regions of the world the water crisis has become so acute that ensuring acceptable access to water in quantity and quality for all users including ecosystems must be managed by adopting a calculated risk approach and at an acceptable level of uncertainty. There is growing agreement that public water policies will face (and perhaps already are facing) challenging trade-offs to achieve water security. While the reallocation of a scarce resource across productive sectors and users is a politically sensitive adjustment, there are less painful trade-offs that can be looked at. Arbitration can be driven by thoughtful policies across supply-oriented approaches (e.g., infrastructures, transfers, storage systems) and demand-oriented approaches (e.g., pricing, planning, and greater use of efficient technologies).

International trade should be considered as a powerful solution concurring to support both demand and supply-oriented responses to the water crisis. When discussing the direct effect of international trade on water, we mentioned some critical areas where progress can be made and where international trade can support. A more concerted and open international trade environment could help secure solutions notably through a sound investment environment for water-related infrastructures and the capacity to source input, technologies, and innovations from abroad. This paper also suggests the existence of an indirect channel through which international trade can support the alleviation of the water crisis through the concept of virtual water. It shows how tightly trade in agriculture (and industrial products) is linked to the use of water and the (relative) availability of the water resource. The fact that a growing number of water-scarce countries are relying on food import is not just the result of an accidental correlation. Through the reallocation of water to higher-value uses at the country and regional level, coordinated trade and trade policies can have a positive impact in balancing out lack of water across countries.

## REFERENCES

- 2030 Water Resources Group. 2009. *Charting Our Water Future: Economic Frameworks to Inform Decision-making*. Washington, DC: The World Bank.
- Allan, J. 1997. Virtual Water: A Long-term Solution for Water Short Middle Eastern Economies? Paper presented at the 1997 British Association Festival of Science, University of Leeds.
- Anderson, R. F. 2010. *Trends in Local Government Expenditures on Public Water and Wastewater Services in Infrastructure: Past, Present and Future*. U.S. Conference of Mayors. Washington, DC.
- Bates, R. 2009. The Trade in Water Services: How Does GATS Apply to the Water and Sanitation Services Sector? *Sydney Law Review* 31(1): 121–142.
- Bucher, H., J. Drake–Brockman, A. Kasterine, and M. Sugathan. 2014. Trade in Environmental Goods and Services: Opportunities and Challenges. International Trade Centre Technical Paper. Geneva, Switzerland: International Trade Centre.
- Boulanger, P. 2007. A Flood of Euros for Irrigated Fields. Policy Brief. Groupe d’Economie Mondiale. Sciences Po.
- Chapagain, A. K., A. Y. Hoekstra, and H. H. G. Savenije. 2005. Water Saving through International Trade of Agricultural Products. *Hydrol. Earth Syst. Sci. Discuss.* 2: 2219–2251.
- Conway, D. 2015. Invention and Diffusion of Water Supply and Water Efficiency Technologies: Insights from a Global Patent Dataset. Working paper. Grantham Research Institute on Climate Change and the Environment.
- Debaere, P. 2014. The Global Economics of Water: Is Water a Source of Comparative Advantage? *American Economic Journal: Applied Economics* 6(2): 32–48.
- Falkenmark, M. 1995. Coping with Water Scarcity under Rapid Population Growth. Paper presented at the Conference of SADC Ministers. Pretoria, South Africa, 23–24 November.
- Hoekman, B. M., K. E. Maskus, and K. Saggi. 2004. Transfer of Technology to Developing Countries: Unilateral and Multilateral Policy Options. Policy Research Working Paper Series 3332. Washington, DC: The World Bank.
- Hoekstra, A. 2010. The Relation between International Trade and Freshwater Scarcity. Working Paper ERSD-2010-05. Geneva, Switzerland: World Trade Organization, Economic Research and Statistics Division.
- Jouanjean, M. A., A. le Vernoy, and C. Simonet. 2016 (Forthcoming). *Price, Water and Trade in Agriculture: An Alternative to the Rain Dance*. Paper under review and written to support the project “Pathways to Resilience in Semi-arid Economies (PRISE).” Publication details to be confirmed.
- Le Vernoy, A., and P. Messerlin. 2011. Water and the WTO: Don’t Kill the Messenger. In *Value of Water Research Report Series No. 54*, edited by A. Y. Hoekstra et al. Delft, the Netherlands: UNESCO–IHE.
- McCool, S., F. Clark, N. Roger, and G. H. Stankey, eds. 2008. Water and People: Challenges at the Interface of Symbolic and Utilitarian Values. Gen Tech. Rep. PNW-GTR-729. U.S.D.A., Forest Service.

- McKinsey and Company. 2011. *Resource Revolution: Meeting the World's Energy, Materials, Food, and Water Needs*. McKinsey Global Institute.
- . 2013. *Rethinking Infrastructure: An Investor's view*. McKinsey Global Institute.
- Muller, M. 2003. *Water 2003: What Should Be Done: Lessons from Johannesburg and Pointers to the Future*. South Africa, Department of Water Affairs and Forestry.
- Myers, N., and J. Kent. 2001. *Perverse Subsidies: How Tax Dollars Can Undercut the Environment and the Economy*. Winnipeg, Canada: International Institute for Sustainable Development.
- OECD. 2012. *Environmental Outlook to 2050: The Consequences of Inaction*. Paris: OECD Publishing.
- . 2011. *Strategic Financial Planning for WSS at National or Regional Level – The FEASIBLE Tool*. In *Meeting the Challenge of Financing Water and Sanitation: Tools and Approaches*. Paris: Organisation for Economic Co-operation.
- ODI. 2005. *Water and GATS: Lots of Smoke But Where Exactly is the Fire?* Briefing papers. December. London: Overseas Development Institute.
- Redor D., and M. Saadi. 2011. International Technology Transfer to Developing Countries: When is it Immiserizing? *Revue d'Economie Politique, Editions Dalloz* 121(3): 409–433.
- Rodriguez, D. J., C. van den Berg, and A. McMahon. 2012. *Investing in Water Infrastructure: Capital, Operations, and Maintenance*. Water papers. Washington, DC: The World Bank.
- Speight V. L. 2015. *Innovation in the Water Industry: Barriers and Opportunities for US and UK Utilities*. WIREs Water 2015.
- Tébar Less, C., and S. McMillan. 2005. *Achieving the Successful Transfer of Environmentally Sound Technologies: Trade-related Aspects*. OECD Working Papers No. 2005/02. Paris: OECD Publishing.
- Wichelns, D. 2015. *Virtual Water and Water Footprints: Overreaching into the Discourse on Sustainability, Efficiency, and Equity*. *Water Alternatives* 8(3): 396–414.
- World Bank. 2016. *High and Dry: Climate Change, Water, and the Economy*. Washington, DC: The World Bank.
- WTO. 1998. *Environmental Services. Background Note by the Secretariat Council for Trade in Services S/C/W/46*. Geneva, Switzerland: World Trade Organization.