



BRIEFING

GLOBAL WATER SCARCITY

Risks and challenges for business



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FOREWORD

FROM THE CHIEF EXECUTIVE OFFICER OF LLOYD'S



The issue of water scarcity is acquiring a new impetus. Not too long ago, it was primarily viewed as part of the suite of issues which make up climate change, but like carbon emissions, it is fast acquiring its own identity and demanding serious attention from

risk managers across their business operations and supply chains.

However, as this report sets out, water is not carbon. It has a unique character, as a shared resource, as necessary for both life and business and as being highly variable in character. Floods and droughts can happen in swift succession and in close proximity.

Lloyd's, the world's leading insurance market, has good reason to pay close attention to floods and droughts. But this report is not simply for the insurance market, or solely concerned with the physical risks of too much, or too little water. It covers a wide variety of issues relating to water use for today's risk manager. How confident are you in your ability to maintain a steady supply of water? Could the record of your suppliers on water management damage your brand or reputation? What new regulations could be imposed on how your company manages water?

The 360 Risk Insight programme is designed to encourage debate on emerging business risks. And this report considers the range of water issues faced by the

business community, from the ability of bottling plants to maintain supply to the tools available to investors or insurers to judge the level of exposure a business has to water risk.

The answers to some of these questions come close to the domain of corporate responsibility. In many of the climate related challenges faced by businesses, there is a close connection between social and environmental policies and self-interest. Water is no exception. One strong lesson from this report is that water needs to be considered at local level, as well as tackled at a national or international level. But across each of these levels is a common theme: sustainability. When we are faced with a shortage of any important commodity, the initial impulse is to acquire more, but this report draws the opposite conclusion – that we should use less, if we are to safeguard ourselves in the future.

Like all our 360 Risk Insight studies, this report on water scarcity forces businesses and risk managers to take a long-term viewpoint, while recommending that they start to take actions now. Over the next few decades, the world will have to make some hard decisions about water. The global population may grow by 3 billion people up to 2050, all of which will need water, and rising prosperity in Asia will further heighten demand. Set against more extreme and unpredictable climate conditions, we in the corporate world will need to find a way to ensure the sustainability, and appreciate the value, of the world's water resources. Not simply because it is right, but because it is necessary.

Dr Richard Ward
Chief Executive Officer
Lloyd's

INTRODUCTION

Business risk around water is rapidly entering the boardroom and risk managers' realm. A few high profile cases¹ have alerted business leaders to these risks and some companies are responding by seeking to put in place systems for understanding and addressing water-related risks to their operations, supply chains and brands.

The increasing public and corporate awareness of climate change over the past decade has focused broad attention on water as a key resource under threat. A 2008 Goldman Sachs 'Top Five Risks' conference identified a catastrophic global water shortage as a greater global risk than soaring food

prices and exhaustion of energy reserves during the 21st Century.

Most businesses will find it difficult to manage all of their water risks alone. Given the complexity of the issues and the political and social importance of water, engagement with civil society, other companies and the public sector is necessary. This report briefly outlines the nature of the global corporate risk around water and highlights ways in which business can better manage this growing risk. The report focuses on water scarcity as the major global issue affecting business, but similar issues often arise where water quality presents risks to companies.

¹ For instance, the Coca-Cola Company has been criticised, and has been the subject of boycotts, because of perceptions that it has over-exploited water resources in India; and Nestlé has been the subject of similar protests by people who object to it selling baby milk powder in parts of the world where clean drinking water is often unavailable. See *In hot water*, The Economist, 6th October, 2005.

EXECUTIVE SUMMARY

1. GLOBAL WATER RESOURCES ARE UNDER THREAT AND BUSINESSES ARE AFFECTED

Economic growth, population shifts and climate change will contribute to severe shortage and degradation of global water supplies and ecosystems over the next 30 years, particularly in the developing world, but not exclusively. Areas such as California and Southern Spain have already been affected by water scarcity issues. Water is critical for many businesses because all goods require water in their production. Companies are increasingly facing a physical shortage of water which, in turn, leads to new regulatory and reputational consequences. Business also needs to consider how governments and the international community will manage water scarcity over the medium to long term. Does the carbon debate offer any useful precedents? What will new regulations look like? And, critically, how can they work with the public and non-governmental sector, not simply to influence the debate, but also to broker solutions – given that water is, perhaps, the world's ultimate shared resource.

2. DIFFERENT TYPES OF BUSINESS FACE DIFFERENT THREAT LEVELS

How will water scarcity affect your business? Companies in sectors such as agriculture or beverages clearly face a direct challenge in identifying sufficient and reliable water sources. But other companies are also affected. Manufacturers need water for their operations, but can be viewed by governments as a lower priority than utility or food production businesses. Some retailers are investigating the sustainability and ethics of how their suppliers use water, in part to combat possible reputational damage. And some parts of the financial services sector are taking a closer look at how their clients are managing their water risks.

3. WATER IS DIFFERENT TO OTHER NATURAL RESOURCES – IT NEEDS TO BE MANAGED ON A LOCAL, BASIN OR NATIONAL SCALE

Water is unique. It is not like coal or oil which we know are finite resources. One river may experience a drought while a neighbouring region experiences flood. The availability and geographical location of water resources are therefore subject to constant change. Water is also a local product. It is difficult to transport and, traditionally, has been used close to its source. So companies working on water management strategies need to look at very local issues, as well as the implications for the wider basin. They also need to consider strategies for engaging with national governments, or even in some cases, international initiatives on corporate best practice around water.

4. TOOLS AND APPROACHES FOR MANAGING BUSINESS RISK FROM WATER SCARCITY ARE ALREADY BEING DEVELOPED

In the last five years, a number of organisations have started developing a range of tools and approaches that can help companies understand and manage their water-related risks. These include methods to map the water footprint of a company's operations and supply chains in different parts of the world (such as the methods developed by the Water Footprint Network and the World Business Council for Sustainable Development); forums for the development of water stewardship standards, potentially leading to some kind of certification scheme (such as that being developed by the Alliance for Water Stewardship); and forums within which companies are exchanging best practice and addressing shared risk issues (such as the World Economic Forum or the UN Global Compact CEO Water Mandate). In addition, a number of NGOs and think tanks are beginning to partner with companies to address risks that also impact on the environment and on local communities, including WWF, The Nature Conservancy and the Pacific Institute.

PART 1

EMERGING GLOBAL WATER SCARCITY



Our global water future

There is a finite amount of freshwater on our planet – only 3% of the total water in the world is freshwater and less than 1% is readily usable by humans². The 20th century saw huge advances in technology and humans’

ability to harness nature for productive purposes. In terms of water, societies developed large dams and infrastructure projects to supply irrigation, hydropower, industrial and urban development. However, this success

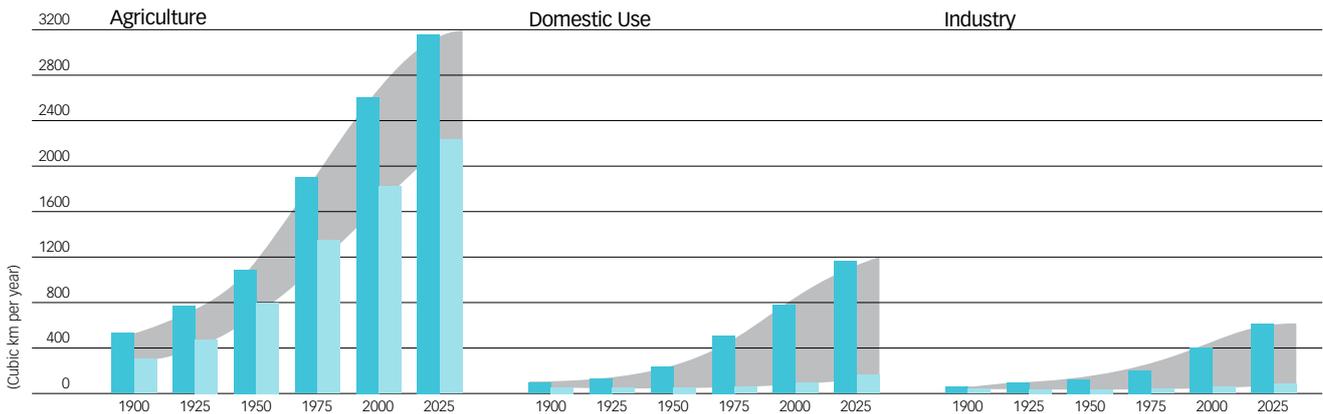


Figure 1: Trends in global water use by sector

■ Extraction ■ Consumption
 ■ Difference between the amount of water extracted and that actually consumed. Water may be extracted, used, recycled (or returned to rivers or aquifers) and reused several times over. Consumption is final use of water, after which it can no longer be reused. That extractions have increased at a much faster rate, is an indication of how much more intensively we can now exploit water. Only a fraction of water extracted is lost through evaporation

Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999.

² While desalination has enabled people to increase the amount of freshwater at a local level, the volume of water affected - and likely to be affected if desalination capacity expands further - is insufficient to alter the global statistics on freshwater availability.

has come at a cost, with rivers and aquifers in many parts of the world drying up. The consequences have become dire for ecosystems and for many people who rely on over-exploited water resources.

Water is used in some way in all manufacturing processes, and all products may be viewed as containing the quantity of water used in their production – this is referred to as embedded water. At the same time, water is, of course, critical for human life and for the survival of almost all ecosystems. The fact that water resources vary from place to place is also distinctive. Risk managers in business need to understand that, in these respects, water is very different to other natural resources such as carbon.

The future of the world's water supplies is undoubtedly a story of increasing stress. What makes it likely that the world's water supply will become more stressed? The short answer is change:

- First, the world's population is expected to peak at about nine billion by 2050. The additional food and water requirements that this implies are significant, given that most of the three billion additional people will live in the developing world, often in places where water resources are already stressed and increasingly in cities which are poorly served by water and sanitation service infrastructure.
- Second, rises in the standard of living in developing countries tends to result in higher per capita water requirements, especially through shifts in demand for different food crops.
- Third, economic growth requires a direct water supply (for increasing domestic, agricultural and industrial use) and the maintenance of water supplies to energy production (for instance, cooling water for thermal power plants, or river flows for hydropower).
- Fourth, increasing water infrastructure development to meet water and energy needs results in the alteration

of freshwater systems and potential conflicts between upstream communities and their downstream "rivals" for water.

- Fifth, climate change predictions indicate greater variability in rainfall in many parts of the world, the melting of ice packs and reduced water availability in many of the current food and fibre producing regions of the world, as well as an increase in flood risk to growing cities.
- Sixth, collapsing wetland, river, lake and estuary ecosystems reduces their resilience and ability to directly provide flood attenuation, waste assimilation and food production.
- Seventh, an increasingly carbon-limited world could restrict the adoption of carbon-intensive technology in the longer term to solve water scarcity, such as energy-hungry desalination schemes and the pumping of water between river basins.

These changes are likely to be exacerbated by the lack of strong and politically independent water management institutions across much of the developing world, which restricts our ability to effectively use water in a changing world.

The increasing scarcity of water raises a fundamental question for the future. Countries and companies will be judged, not by the fact that water will become increasingly scarce, but rather by the way in which they jointly manage and share this precious resource. Three distinct pathways may be foreseen: first competition over water will increase through conflict and protectionism; second commercialisation of water or agricultural products containing water will lead to increasingly variable and risky markets driven by climate change; and third, cooperation will lead to the equitable, efficient and sustainable management of water resources. This distinction is particularly dramatic because 60% of the world's freshwater resources lie in rivers, lakes and aquifers that are shared by different countries.

Looking ahead to a world with greater water stress, it is quite probable that there will be increasing price instability, especially in agricultural markets as demand for water-dependent commodities outstrips production. The associated political, social and economic risks will be most dramatic for countries that are net importers of food, and the financial risks will be most severe for businesses that are dependent on these commodities in their supply chains.

The widespread protectionism and trade controls that were imposed by some countries at the height of the 2008 food price spikes, together with the political instability and food riots in other countries, could be a sign of things to come. It is not too far-fetched to imagine a situation in which countries impose controls or tariffs on the export of commodities with significant amounts of embedded water.

Global water resource hotspots

Figure 2 on the following page provides a scarcity map of the world's water resources, showing river basins that are already stressed. It is important to recognise that many of these stressed river basins coincide with areas of population shift, rapid economic growth (often combined with profound poverty among large sectors of the population), infrastructure development, ecosystem collapse and/or climate change. The varying nature of the global challenge and risks for water management are illustrated by the range of situations highlighted in Figure 2.

The developed world is experiencing relatively low population and economic growth and so water demand is only gradually increasing. However, in the more arid areas such as California, Eastern Australia and Southern Spain, water resources that are already highly developed are expected to become less available and more variable due to climate change. Serious economic, social and ecological trade-offs are already evident and will continue to be necessary between sectors and users, particularly for the huge agricultural sectors in these areas.

On the other hand, most of the developing world is experiencing significant demographic and economic

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growth, with rapidly increasing food, energy and water requirements. South Asia is a particular hotspot, where the over-exploitation of water resources is being driven by a high – and still growing – population density, massive expansion of hydropower requirements, climate variability, transboundary political tension, poor water governance and widespread ecological collapse of freshwater systems.

Sub-Saharan Africa has a low population density, but this is growing, and this region also has endemic poverty, limited infrastructure and a largely uncertain climate future. However, the predominantly transboundary river basins in Africa are likely to be pressured by significant agricultural, mineral extraction and hydropower development. Environmental considerations are significant in regions such as Brazil, which have largely adequate water supplies, but huge hydropower needs. Here the threat of rainforest loss to agricultural or savannah land is a further concern.

Finally, China is experiencing high economic growth, along with a slowly growing, and increasingly urban, population. Both of these trends will have major food, energy and water requirements. China suffers from the entire suite of water problems from over-abstracted rivers and aquifers in the arid north, to flood-prone rivers in the south, with water quality an issue in many parts of the country. The challenge of continually growing a production-based economy with increasingly stressed water resources and degraded river systems may eventually play a role in encouraging China to shift its economic model.

Figure 2. **Global water resources hotspots**

Key

-  Physical scarcity
-  Near physical scarcity
-  Economic scarcity
-  Little or no scarcity
-  Not estimated

Scarcity legend:

Physical scarcity: is defined around the low availability of water per capita

Economic scarcity: is related to lack of infrastructure for reliable supply

Source: Comprehensive Assessment of Water Management in Agriculture, 2007



1 California

Stable economic and demographic growth allows for a fairly predictable future. The big challenge is in less water due to climate which will drive changes in what is currently a predominantly agricultural and high tech economy.

2 Southern Amazon

There is significant potential for further hydropower generation in the Amazon basin. But climate change may induce a shift to a savannah ecosystem in parts of the Amazon; this may in turn affect regional climate patterns and surface runoff, with potential implications for hydropower generation. Deforestation remains a key challenge, for similar reasons.

3 Northern Europe

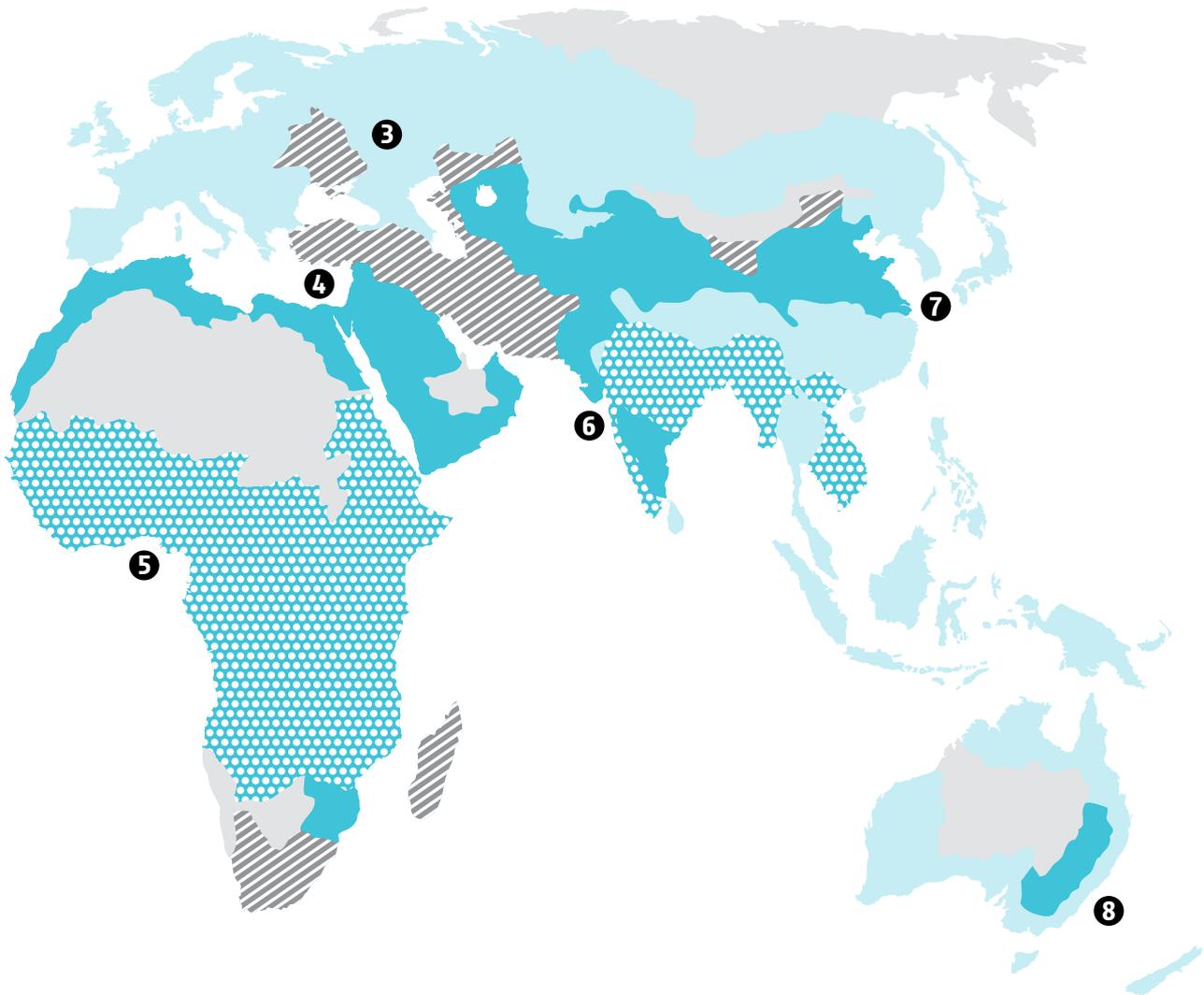
Water quality and flooding are the main problems in a region with a less variable hydrology.

4 Mediterranean and Middle East

North Africa and Southern Europe face challenges of water stress that will be exacerbated by climate change.

5 Sub-Saharan Africa

There is high population growth and economic growth but from a relatively low current population and level of economic development. There is high stress in basins with existing development exacerbated by variable hydrology.



6 Northern India

There is high population and economic growth in an area of already stressed basins; and there are a number of shared basins in areas of geopolitical instability.

7 China

There is low population growth but massive economic growth. The north is arid and will become more stressed with climate changes, while the south is prone to flooding and water quality problems. The future is unpredictable because of the scale of the expected changes.

8 Australia

The resource based economy (agriculture and mining) will be significantly impacted by climate change adding to the already significant water stress in the south eastern parts.

The globalisation of water

All goods and commodities have water embedded in them, equivalent to the water required during their manufacture, as well as the production of all the inputs used in the manufacturing process. Until the Industrial Revolution, most inputs were sourced relatively locally; thus water was normally used within a relatively short distance of its source. In the 19th and 20th centuries, the large-scale development of dams and pipelines supported the massive expansion of agricultural irrigation areas and the growth of industrial manufacturing zones, often in locations far away from the rivers or aquifers where water is sourced.

At the same time, the increasing globalisation of trade has created an unprecedented rise in the international movement of goods. Because all products contain embedded water, this creates a “virtual” global water trade. A consequence of this is that any single country is now far more dependent than ever before on the

availability and good management of water resources in distant locations. This is illustrated in Figure 3, which shows the so-called water footprint of the UK's consumption of agricultural produce from across the world: the thickness of the arrows and the shading of each country is proportional to the volume of virtual water which the UK imports in the form of agricultural produce grown in that country. As a result, the UK is heavily reliant on the water resources of countries such as Brazil, France, India, United States, Argentina and some West African countries.

Global trade in agricultural commodities and the price of these commodities on international markets are significantly dependent on seasonal variations in climate and water. After a steady decline in prices over the previous half century, the UN Food and Agricultural Organisation's food price index increased sharply during the last decade, and in particular in 2007–08. This was due to a combination of growth in biofuel cultivation (which led to a decrease in supply of other commodities), increasing demand, high oil prices, speculation in food markets and, importantly, extreme weather events, including drought in

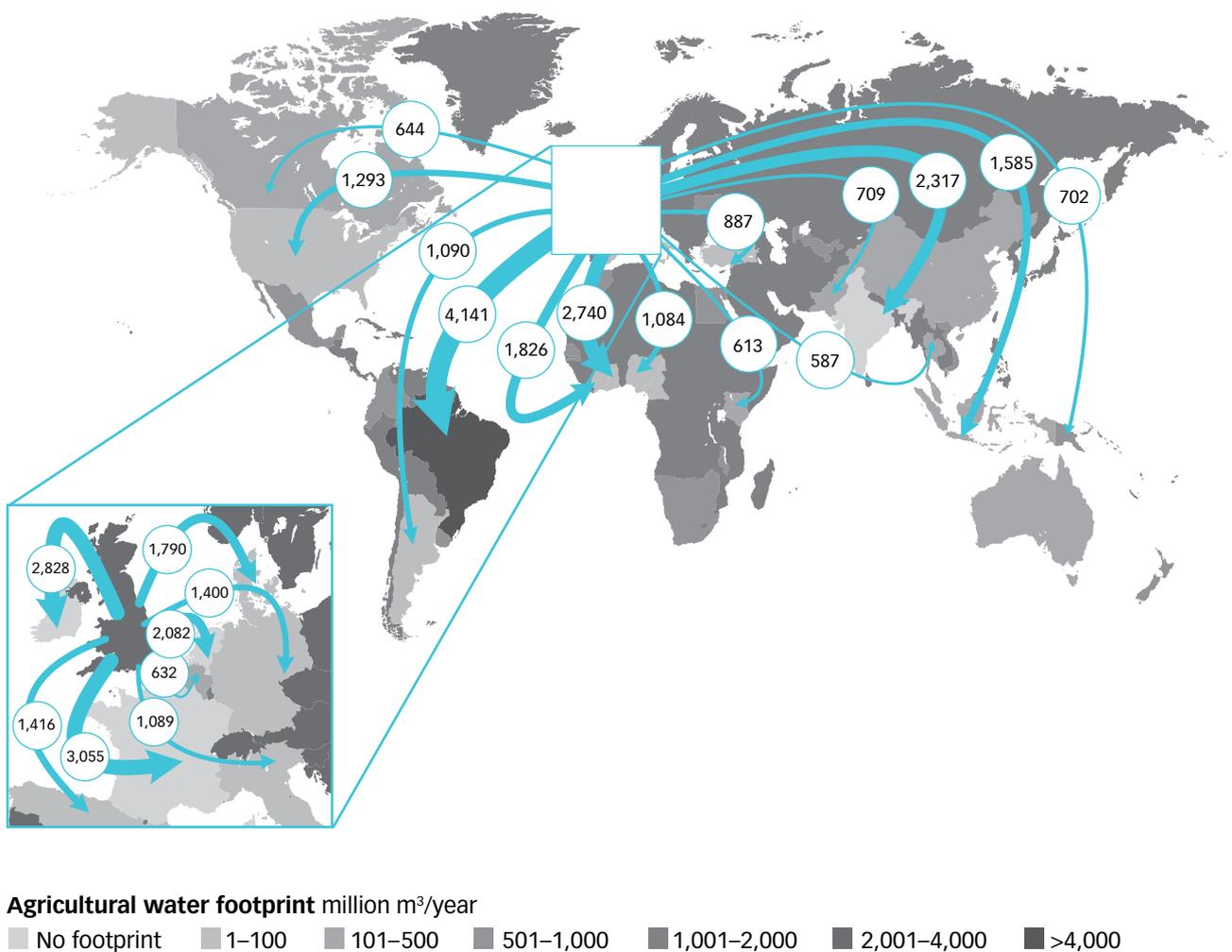


Figure 3: **The external water footprint of the UK's agricultural imports** (source: Chapagain, A. and Orr, S. 2008, UK Water Footprint: the impact of the UK's food and fibre consumption on global water resources, WWF-UK, Godalming)

grain-producing countries such as Australia³. Significantly, food prices dropped to 2006 levels after the onset of global recession in September 2009, which further highlights the nature of global commodity price instability.

This interaction between climate, water, food and energy in commodity price risk was even more clearly reflected by the increase of sugar prices to record levels during August 2009⁴. This seemed to be a response to projections of reductions in supply due to weaker monsoons in India and irregular rains in Brazil (ie water scarcity), as well as the Brazilian shift to sugar-based ethanol production, all of which led to a downturn in production; and increasing demand for sugar in Asia. Speculation provided the fourth element of this “perfect (market) storm”.

While it may be argued that this is simply the natural consequence of free markets, price instability – which is closely linked to water scarcity – poses risks to countries, companies and communities that depend on these crops.

What is different about water risk?

Parallels have been drawn in the public consciousness and corporate boardrooms between the potential water crises in the 21st century and the ongoing energy and carbon crisis. While both relate to a global resource, great care must be taken in transferring approaches developed for carbon management to the water debate. It is critical to

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recognise that water is fundamentally different to carbon and other natural resources for a number of reasons.

- Water availability is variable in time and space and therefore its short and long-term future availability is uncertain. One river basin may be suffering extended drought while neighbouring river basins may be experiencing devastating floods. Equally, a given river basin may experience droughts and floods in quick succession. Understanding operational and strategic risk around water is therefore different from understanding natural resources, such as minerals or forests, which tend to be more static.
- Water is a finite, but renewable resource, the availability of which is physically constrained by the infrastructure available and legally constrained in many places by complex historical water rights systems.
- Water is non-substitutable in most domestic and productive activities, although it may be more efficiently used. The risks associated with scarcity are therefore very real at a river basin scale. Put simply, while there may be substitutes for carbon in energy production, only water can be used for drinking or for irrigation.
- Water is, essentially, a regional product. It is bulky and costly to move in the volumes typically required for production, so it can only be transferred between neighbouring river basins up to about 500km (or even

³ For more on the 2007–2008 food price shock, see *The state of food and security in the world* by the FAO, www.FAO.org

⁴ The FAO Sugar Price Index showed that International Sugar Agreement daily prices rose from an average of US 11.90 cents per pound in October 2008 to US 16 cents per pound in May 2009 and reached a 28-year high of US 25.18 cents per pound on 31 August 2009. See www.fao.org

The key message for companies to understand is that water risks are experienced firstly and predominantly by people and ecosystems at the local/river basin scale. So any successful risk management approach must be based on finding solutions that work for the business and for local water users.

shorter distances where it needs to be pumped uphill). Because of this, and due to the flow of water from upstream to downstream users, risks and responses must be understood at a river basin scale, not at a global scale, as is the case with carbon.

- Water is fundamental to life, human dignity and all ecosystems. In addition, rivers are fragile ecosystems, to which human settlements have historically been closely linked – for transport, water use and waste disposal, and through spiritual beliefs. However, these social, cultural and ecological dimensions are juxtaposed with the economic value of water related to its use in various production processes. So more than most natural resources, water management requires getting to grips with traditional economic risks associated with

the scarcity of an economic good, and political risks associated with water as a public interest social and ecological good.

The distinctive character of water as a resource means that different risks and different aspects of its use need to be addressed at different scales:

- At the local level – a lack of drinking water, competition over water or the high cost of water
- At the river basin level – allocation of water, management of floods and water quality
- At the national level – policy and institutional capacity to manage water resources
- At the regional level – geopolitical disputes over water and energy
- At the global level – trade implications related to commodities with embedded water

The risks facing a particular company or country are interwoven with these complex water management challenges. The key message for companies to understand is that water risks are experienced firstly and predominantly by people and ecosystems at the local/river basin scale. So any successful risk management approach must be based on finding solutions that work for the business and for local water users.

PART 2

BUSINESS RISK FROM WATER SCARCITY

Water scarcity provides business opportunities for some, whereas it may threaten the operations or supply chains of others.



What about future corporate water risk?

Companies are operating in an increasingly uncertain world, with this changing water future adding yet one more dimension of risk. The first challenge for any business is to understand its own exposure to water-related risks. Water scarcity provides business opportunities for some, whereas it may threaten the operations or supply chains of others. Although some are able to shift operations or supply chains with ease, others are constrained by political issues, the need for market proximity or by the degree of investment in a particular location. All of these risks are set against the institutional capacity and political maturity of the countries in which water is being used for production or through the supply chain.

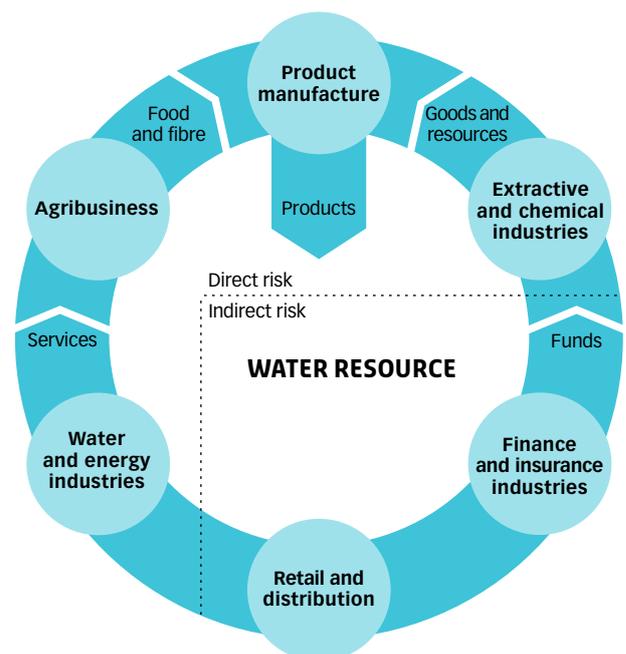


Figure 4. The link between water and key business sectors

Consider the distinct water risks of the six broad business sectors indicated in Figure 4. Furthermore, think about the water, commodity and financial flows between these sectors (and among external parties).

- **The water and energy industries** develop and operate the infrastructure required to ensure that water and energy of adequate quality and reliability are available to users. Business opportunities arise from increased water demand, particularly where capital finance is available and operations can be funded from fiscal or user-based income streams. For instance, an energy utility may be able to profit from the construction or operation of a new hydropower scheme to supply electricity to a growing economy. Furthermore, an engineering consultancy may find new business by managing the construction of urban water supply infrastructure to growing cities. However, these opportunities may attract increasing social and political concern over privatisation.
- **Agri-business** requires significant amounts of irrigation water to grow and process food and fibre products, and is constrained by land and water availability. Further irrigation expansion is limited and in the more developed economies, it is under threat from higher-value urban users. This poses the politically challenging options of either buying up local farmers' land or locating the business in countries which have available water and land. Both options raise difficult national food security questions. At the same time, as seen in the contribution of water shortages in Brazil and India to the rapid increase in world sugar prices in 2009, increasing climate variability may create unstable commodity markets, which will only benefit those companies that are hedging or speculating in these markets.
- **Product manufacturing** also requires water for its operations and in many cases is dependent on water-intensive agricultural products. Although urban and industrial water supplies are typically a government priority, the challenge of ensuring reliable water of adequate quality at the factory gate is likely to remain significant for companies operating in many developing countries. While this has often been taken for granted in

developed economies, water infrastructure challenges are becoming more common and these will be exacerbated by climate variability. For some companies, they may be compounded by the instability of agricultural input commodity prices driven by climate variability.

- **The extractive and chemical industries** have some water requirements, but their biggest risk remains the impact of waste discharge on water quality, with consequences for downstream users and aquatic ecosystems. These are often strategic national industries, with privileged access to government, but their negative impacts on local water resources can bring political heat and market censure. The availability of raw materials typically dictates the location of their operations, which precludes relocation to manage water risk.
- **The financial and insurance industries** do not need much water directly, but they do need to consider the risk to their investments or the cover they provide to clients who are dependent on water, particularly where this is linked to a specific river basin, which is suffering from water scarcity. Insurance could play a role in helping businesses to manage their increasing risk and exposure around water. On the other hand, commodity traders may thrive on water-related uncertainty in agricultural commodity markets.
- **Retail and distribution** does not use much water, but because it is at the end of the value chain, retail can be significantly exposed to public opinion. This issue is particularly acute for those retailers with strong corporate responsibility and stewardship-based brand values, which could mean that these retailers share water risk and responsibility with their suppliers.

In all of these situations, it is imperative that an individual company understands water risk, both in its operations and along its supply chain. Water risk starts at the most upstream supplier, in terms of its use of water, flows through intermediate suppliers to the company's operations, and then continues downstream, in terms of clients' and customers' perceptions, and their water requirements in using the company's products.

Understanding business risk related to water scarcity

Future challenges around water may be divided into a number of inter-related dimensions of risk for business:

- **Physical** risk directly relates to a shortage of water (scarcity), too much water (flooding) or water that is unfit for use (pollution). These risks are exacerbated where water management institutions are unable or unwilling to exercise control over the use of water from, or the discharge of wastewater to, a given river or aquifer. Secondary risk is related to a lack of capacity in many countries to physically deliver water supply and wastewater disposal services through infrastructure systems.
 - These types of risk are illustrated by SABMiller's experience in two African cities. In the first case, the brewery in Dar es Salaam in Tanzania has faced threats to supply from saltwater intrusion into the 20 boreholes feeding its operations. On the other hand, in Polokwane in South Africa, the SABMiller brewery has faced deteriorating reliability and quality from the municipal water supply, despite adequate water being available in the region.
- **Regulatory** risk relates to the imposition of restrictions on water use by government. This may include the pricing of water supply and waste discharge. Although regulation and pricing can be key elements of a sensible water management regime, experience suggests they can also be a symptom of incoherent or inconsistent government policies. Regulatory regimes may be

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changed unpredictably and water licences may be revoked in response to physical or political crises, often related to water scarcity. Regulatory risk increases where failures in water management policy or capacity are neglected for short-term gain.

- The Almeria area in southern Spain illustrates issues around regulatory risk, highlighting that this is not only a developing country phenomenon. Almeria is one of the most arid regions of the EU, but also has some of the highest agricultural output. Agricultural production is the backbone of the local economy, making water allocation and quality a sensitive political issue. The government has developed a number of transfer schemes and desalination facilities to support agricultural production. Despite these efforts, groundwater resources have seriously deteriorated. This decline has been caused by several factors. The local government has failed to price water consumption appropriately, with different systems for desalinated water, transfer schemes and groundwater, of which the last is the least expensive. Growers have therefore continued to rely heavily on depleted groundwater, using other types of water as "top ups". Moreover, the local government has issued further licences for agricultural expansion. This district is likely to face long-term challenges, and in response to this, retailers such as Marks & Spencer have begun to demand improved water efficiency and resource management, because of the risk they face from being associated with these practices.

- **Community** risk, and closely associated reputational risk, is manifest through tensions and conflict around access to water or the degradation of local water resources. This in turn creates an unsteady social, political or regulatory environment, which is not conducive to stable business operations due to employee or supply chain disruption. Under socially and politically unstable conditions, companies may be blamed by local stakeholders because they provide an easy target, even though the companies themselves are not directly responsible for local social or ecological problems. At its extreme, local violence may erupt between different water users.

- **Reputational** risk, which often arises where community risk has increased, affects a company's brand and can influence customer purchasing decisions. In a highly globalised information economy, public perceptions can emerge rapidly around business decisions that are seen to impact on aquatic ecosystems or local communities' access to water. These perceptions may even develop where a company's operations or supply chains are linked to a river basin that is subject to ecological or social concerns, despite little causal linkage being demonstrated.

- The experience of The Coca-Cola Company at Plachimada in the Palakkad district of the state of Kerala in India provides an example of the interplay between social perceptions, regulations and reputational concerns. This area is mostly dependent on groundwater resources for agricultural irrigation and domestic use. As the population of the area has grown, groundwater boreholes have increased to serve the needs of the local population. In 1999, the local government granted Hindustan Coca-Cola Beverages (HCBL, the company that produces Coca-Cola under licence from The Coca-Cola Company) a licence to abstract between 0.3 and 0.6 million litres of water per day for its operations. Over the next four years, rainfall in the area decreased considerably, placing further stress on an already over-allocated groundwater resource. In 2002, the local community, supported by domestic and international NGOs, began to protest against the HCBL plant, blaming it for the deterioration of groundwater resources in the area. This sustained action forced the government to re-evaluate the HCBL licence and its impact on the area. This eventually led to the water abstraction licence being revoked, negative Coca-Cola brand perceptions in the US and elsewhere, and more recently a requirement to pay damages to the local community. Since this experience, The Coca-Cola Company has taken a closer interest in the community impacts and water-management performance of its bottling plants.

- **Investment** risk revolves around the possibility that, as understanding of water risk spreads, water-related disclosure requirements will be placed on investors and retailers. This is most likely to occur through the establishment and mainstreaming of formal accreditation (labelling), stewardship standards and disclosure metrics around water.

- The Carbon Disclosure Project (CDP) has recently launched the CDP Water Disclosure initiative, which aims to provide critical water-related data from the world's largest corporations to inform the global market place on investment risk and commercial opportunity⁵. CDP says that, as part of this initiative, it will request information on the risks and opportunities companies face in relation to water; on water usage and exposure to water stress in companies' own operations and in their supply chains; and on companies' water management plans and governance. This data will provide valuable insight into the strategies deployed by many of the largest companies in the world on water and will be used to help attract investment to sustainable water use. In addition, large multi-national banks, such as HSBC and Standard Chartered, have in recent years issued position statements or lending policies on water, which suggest that they will increasingly be taking water-related risks into account when making investment decisions⁶.

- **Geopolitical** risk relates to the potential for conflict or political disagreement over transboundary river basins, or national political imperatives, such as trade restrictions on food crops with embedded water. These types of risk are currently not particularly prevalent, but may emerge in a changing global economy stressed by climate change. Although armed conflict between countries over water may occur, perhaps the greater threat to business lies in regional political and trade disputes, which disrupt water sharing, energy pools and food trade between countries on large rivers. The threat of climate change, water stress and increased food

⁵ www.cdproject.net

⁶ www.sustainability.standardchartered.com (see link to position statements) and www.hsbc.com (click on the sustainability tab, then on the link to sustainable finance)

requirements has led Asian countries and Gulf States to buy or lease large areas of land and water in less developed countries, often through national corporates. The geopolitical consequences of water scarcity are likely to grow as resources become scarcer.

- These types of geopolitical risk were seen in a recent coup in Madagascar which, it has been argued, was partly the result of attempts by South Korean interests to take long-term land and water leases⁷. The conflict in Darfur has also been attributed by the UN Secretary General Ban Ki-moon to competition over scarce water resources, exacerbated by the onset of climate change⁸.

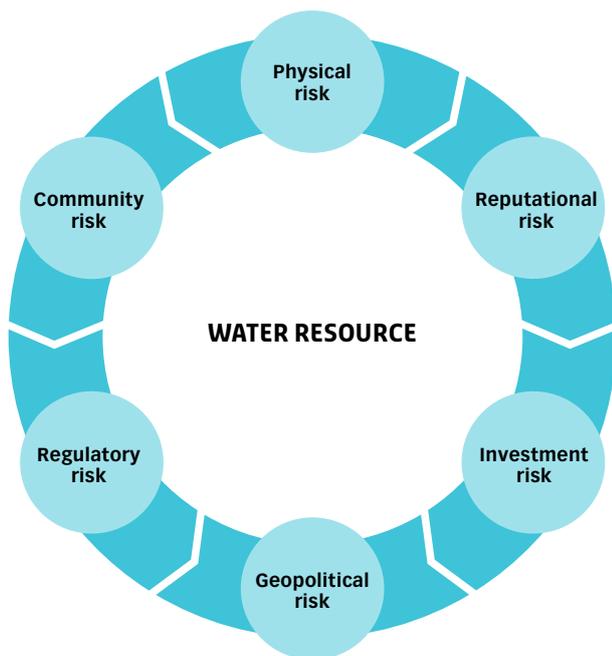


Figure 5. **A typology of water-related risks to business**

Any of the risks shown in the diagram may be relevant for a company operating in a given country, river basin, product line or market. As with any risks, they may manifest individually or in concert. Ultimately, these risks have financial impacts on company profit, by increasing input, operating or transaction costs, or by restricting sales or revenue.

⁷ See *The Scramble for Land in Africa*, The Economist, May 21st, 2009

⁸ See *A Climate Culprit in Darfur* by Ban Ki-moon, The Washington Post, June 16th, 2007

⁹ See www.sabmiller.com for more information about SABMiller's water management activities

The companies that are engaging with water risk in the most comprehensive manner, such as SABMiller⁹, are doing so primarily by recognising the current or medium-term physical risk of water scarcity to their operations, and to a lesser extent their supply chains. The first fundamental message is that businesses are increasingly engaging with risks around competition for water in stressed river basins.

The second fundamental message is that in a world where the global movement of commodities, and therefore of embedded water, remains an important element of the economy, there is greater risk for companies linked to rivers with ecological or social water problems. Having the legal licence to operate, and ensuring internal operational water efficiency, may not protect a company against government, public or customer actions. Given the highly political, social and ecological nature of water, it is often necessary for a company to recognise and build the social licence to operate around water concerns of local communities in its areas of operation. Although this may seem like corporate social responsibility, it is increasingly being acknowledged as an important part of operational risk management.

How water scarcity contributes to shared risk

The high value horticulture industry on the shores of Lake Naivasha in Kenya has been an economic success story over the past three decades. Not only is the sector a major foreign exchange earner but it has also attracted job seekers from across Kenya. However, this is placing a significant strain on local service infrastructure, which does not have the capacity to absorb such a rapidly growing population. Economic development has had a cultural impact by restricting the movement of traditional pastoralists, who have historically had free access to the lake. These pressures also have an ecological dimension; commercial farmers have been accused of over-abstraction and degrading the ecologically important

lake, and population growth is causing human waste and pollution to accumulate. These negative ecological consequences have led to calls for European customers to boycott Naivasha flowers¹⁰.

This example demonstrates the potential convergence around water of corporate risk and government risk, both of which have important economic, social and ecological aspects. Mutual interest between the private and public sectors introduces the opportunity for joint action in engaging this shared risk. This shared risk paradigm means that a significant portion of the discourse around corporate engagement will cover water-related risks beyond the factory gate, or supply chain.

A second dimension of shared risk relates to the inter-relationship between companies along the value chain of a product. For instance, European retailers share risk with Naivasha flower growers, either in terms of their brand or in terms of the continued production of flowers. This water scarcity-induced joint risk along the value chain is prevalent in the food, fibre and energy markets.

The business proposition for managing water risk

It is probable that at a certain point most companies will face some of the water-related risks outlined above, in their operations or associated supply chains. This is most likely for those in the primary economic sectors of agriculture or extractive industries, followed by the water-intensive secondary sectors of manufacturing, construction and infrastructure (utilities). The tertiary service sectors of finance, retail and government largely face risks through their associations and relationships with the companies in the more water-dependent sectors.

The motivation for a company to engage with water issues ranges from operational to ethical values, and depends on its exposure to the following water-related risks:

- First, a response to an operational crisis around water availability or water-dependent inputs in a specific area or river basin – an example is Anheuser-Busch’s response to water, hops and hydropower electricity shortages, as a result of drought in the north-western US.
- Second, a strategic risk to operations or supply chains, due to an expected future change in water availability or requirements in an area or river basin – an example is the Anglo-American government initiative to develop a basin water management strategy in South America, and thereby secure future water requirements.
- Third, the positioning of the company relative to competitors in response to client or market perceptions around the importance of water stewardship or risk mitigation – an example is Marks & Spencer promoting water stewardship to their agricultural crop suppliers.
- Fourth, corporate social responsibility initiatives or an interest in being perceived by the public, clients and employees as sector leaders – an example is the HSBC water partnership with WWF.

The business case for engaging with water risk will clearly differ between companies. However, most risk managers should now be looking at how water scarcity could affect their company. Strategic management of this risk requires a risk assessment, clear articulation of the rationale for managing the risk, and planning how to mitigate the risk.

¹⁰ See for instance *Lake Naivasha: Withering Under the Assault of International Flower Vendors*, 2008, Food and Water Watch and The Council of Canadians/Le Conseil de Canadiens (www.foodandwaterwatch.org)

PART 3

CORPORATE STRATEGY AND OPPORTUNITIES



Water risks continually change and therefore responses need to be flexible with scope for adaptation to changing circumstances.

Water risk management at a strategic corporate level has only emerged in the past five years. Traditionally most companies have managed water risks at an operational level and lobbied government around public water policy, law and regulatory changes. Water issues were often only considered in terms of corporate social responsibility.

As a consequence, water risk management is a creative and dynamic space, with great diversity in opinions, approaches and initiatives. Different companies are trying different things, depending on the nature of risks they face, as well as their individual motivations and organisational cultures. Nevertheless, these initiatives share a number of common approaches.

First, most companies begin with an attempt to understand and quantify the nature of their water-related risk, and follow this with appropriate policy, strategic or

operational responses. The important message is that, as with all risks, water risks continually change and therefore responses need to be flexible with scope for adaptation to changing circumstances.

Second, companies focus engagement around their operations and/or upstream supply chains, depending on the nature of their water risks. This is fundamentally driven by the nature of their business sector, with water-dependent businesses engaging with operations, companies processing agricultural products addressing operations and supply chains, and retail and financial businesses focusing on supply chains.

Third, companies engage at a range of levels, from internal company processes and supply decisions, through local or river basin level governance, to national and even global policy discourse. The nature of response at each of these levels deserves further clarification

and illustration below, because this lies at the core of a company's risk mitigation strategy.

Fourth, an increasing number of companies have mainstreamed water risks into their corporate operational risk domains, with their response being largely funded by operational budgets. This marks a shift from the situation five years ago, where water was deemed to be part of sustainability or corporate social responsibility.

Fifth, the diverse political, institutional and social conditions among developed and developing countries result in different types of exposure to risk. The nature of responses and requirements from companies also tends to differ. Water risk management in developed countries typically focuses on concerns over environmental reputation and regulatory negotiation. Water risk management in developing countries is typically more interventionist, requiring social and institutional action in the absence of clear policy or bureaucratic capacity.

Understanding water risk

Each company obviously has its own risk assessment methods, into which water risk may be incorporated. However, there are two emerging methods to assess water risk, which are widely used by companies that depend on water in their operations and/or supply chains.

The first risk assessment method is corporate water footprint¹¹ analysis, which provides a direct (operational) and indirect (supply chain input) volumetric indicator of water consumed per unit of product (often measured in terms of litres of water per litre of beverage or kilogram of soap, for example). The water footprint does not yet adequately deal with the environmental impact of wastewater discharge, so related statistics need to be interpreted in the context of water availability and stress at a river basin scale. Water footprint analysis seems to be favoured by companies that are significantly dependent

on water through their supply chains, such as the food, beverage and household product sectors.

The second risk assessment¹² method is Life Cycle Assessment (LCA), which indicates the environmental performance of a product or operations, including impacts on freshwater supply. Although LCA provides a comprehensive method for understanding the direct consumptive and discharge impacts of a product, it is less well suited to assessing impacts along the supply chain. LCA appears to be more relevant for companies that have a significant direct impact on water resources, such as the extractive, chemical and utility industries.

For obvious reasons, these methods do not resonate with those companies that are not directly exposed to water risk. However, investors and insurers are increasingly recognising the need for water-dependent businesses to disclose their water risks, and are beginning to develop client-oriented water risk assessment methods, as part of broader risk assessment processes. Metrics are also being developed to assess the risk to investment in specific river basins, based on water availability, social stability and institutional capacity.

Regardless of the risk assessment approach, there are some key aspects of water use and resources that corporate risk managers must analyse in evaluating water risk including:

- How much water the company uses and discharges and whether using this volume is legal in the location in question.
- Which other water users depend on the same water resources and the cumulative impacts.
- How effective is river basin governance and the enabling policy framework.
- What is the impact of future demographic, economic and climate change.

¹¹ Water Footprint Network: www.waterfootprint.org

¹² See UNEP/SETAC Life Cycle initiative at www.estis.net

What the international corporate community is doing

The increasing interest in water shown by businesses has led to various global corporate initiatives. These provide platforms for largely multi-national corporations to share emerging practice, agree on common approaches and engage with multi-lateral organisations, governments and international non-governmental organisations. The three most relevant are:

- The World Economic Forum (WEF) Water Initiative, begun in 2006 to discuss the geopolitical and economic issues pertaining to water security and risk. The WEF has moved this agenda forward by assisting in the creation of country partnerships and is currently attempting to create a facility that will support corporate-government engagement around water issues.
- The CEO Water Mandate was created under the auspices of the UN Global Compact in 2007 to promote and support the development, implementation and disclosure of water sustainability policies and practices by private companies.
- The World Business Council on Sustainable Development (WBCSD) Water Task Team provides a forum for companies to engage around water issues and has assisted in the development of tools to support corporate assessment of risk.

Disclosure and accreditation around water risk

Water risk disclosure initiatives have recently emerged following increased investor awareness of water risk and carbon disclosure initiatives. As discussed above (see explanation of Investment risk), the Carbon Disclosure Project is in the process of reviewing, consulting and developing disclosure requirements, and the

International Organization for Standardization (ISO) is formulating accreditation requirements based on the above metrics. Many companies are watching this space with interest and some concern given already significant global reporting and compliance requirements.

A further dimension is the accreditation of companies or products that have achieved a specified standard (checklist) of good stewardship. During 2010, the Alliance for Water Stewardship¹³ will be holding a series of roundtables to develop standards. An outstanding debate is the degree to which these standards reflect internal company policy or relate to conditions in the river basin within which a company operates.

Companies' management of direct water risk

As one would expect, companies respond to water risk in different ways. However there are three fundamentally different modes of response for companies that face direct water risk to their operations or in their supply chains:

Responses that a company has direct control over

The first and simplest response is to reduce the volume of water required and waste discharged, through operational efficiency and recycling. This is particularly relevant where these operations are in a river basin with existing or threatened stress, or water quality concerns.

- SABMiller has set operational water efficiency targets across the group to reduce water consumption per litre of beer by 25% before 2015.
- Levi Strauss & Co has set waste discharge standards for its operations and direct suppliers that may exceed local discharge standards in some countries.

An alternative, potentially related approach is the selection and/or influencing of suppliers to minimise joint or transferred risk.

¹³ See www.allianceforwaterstewardship.org

- Marks & Spencer has recently developed guidelines for its agricultural suppliers on water efficiency and stewardship and is working with suppliers in selected areas.

All of these approaches require that a company gets its house in order and are prerequisites for effective engagement beyond the factory gate. Underlying these approaches is the necessity for legal compliance, in terms of local or national water abstraction and/or discharge permit conditions, or the acceptance of international norms where the local regulatory regime is inadequate.

Responses that address water scarcity or river basin concerns

Water use efficiency does not by itself immunise companies from water shortage or the potential reputational and regulatory consequences of being located in a river basin with social tension or ecological collapse related to water scarcity or contamination. The second response mode involves engaging with other stakeholders to improve the management of water resources. This type of engagement typically occurs at the local/river basin scale and is most effective where a company recognises the diversity of stakeholder perspectives, but in the context of shared risk.

On the one hand, companies have worked with communities close to their operations, to improve the local communities' access to water for domestic purposes.

- Having made water efficiency savings within local operations, Anglo Platinum worked with local communities in Rustenburg in South Africa to assist them in accessing household water on the basis that total water use would not increase.
- The Coca-Cola Company requires all operations to develop water source protection plans with local stakeholders by 2013, based on an understanding of river basin vulnerabilities.

On the other hand, companies have directly engaged and even supported local government or water user

Companies may need to engage river basin managers, stakeholders or processes to advocate improved water management. Their focus rests not only on accessing water for the company's operations, but on achieving more equitable, efficient and sustainable management, which will mitigate unforeseen ecological, social or regulatory problems.

associations to improve the reliability or quality of water supply, or to address local social or ecological concerns.

- Flamingo Flower Holdings has been working through the local water user association in Lake Naivasha in Kenya to improve river basin management of water resources.
- SABMiller provided funding and support to the Polokwane Municipality in South Africa to improve the reliability and quality of supply from its water treatment plant.

Companies may need to engage river basin managers, stakeholders or processes to advocate improved water management. Their focus rests not only on accessing water for the company's operations, but on achieving more equitable, efficient and sustainable management, which will mitigate unforeseen ecological, social or regulatory problems. This is usually through participation in multi-stakeholder platforms, linked to water management institutions.

- SASOL (a South African chemical/fuel derived from coal business) has been an active participant in the Vaal River basin planning process, advocating for greater controls over illegal water use in agriculture and supporting municipal water efficiency initiatives.
- Anglo American is investing considerable capital in mining operations in South America, and as its largest water user, the company is developing a river basin water strategy in collaboration with government authorities, to improve clarity around future water allocation and management.

Increasingly companies are entering into dialogue with national government to improve policy and institutional capacity at a river basin level.

- The Coca-Cola Company and SABMiller, in collaboration with WWF, have developed a “payment of environmental services” initiative in Honduras to assist upstream communities in reducing their soil loss and thereby sedimentation of valuable downstream freshwater and marine ecosystems.

Responses that influence the enabling framework or discourse

Some companies have lobbied government against national policy, legislation and strategy that imposes greater regulatory requirements in the water sector. However, increasingly companies are entering into dialogue with national government to improve policy and institutional capacity at a river basin level. This third mode of engagement stems from the perceived greater risk of inadequate coherence, consistency and stability around water management.

Typically this involves arms-length engagement through national sector or business associations, in order to distance individual companies from any negative government perceptions. So far it has tended to focus on calls for improved water allocation, control and enforcement, as well as water pricing and trading as a means of economically efficient water allocation. Although these corporate positions are economically and theoretically sound, they often ignore or simplify the political, social and ecological nature of water. If this process of engagement is not transparently managed, it can feed into negative government and civil society perceptions about companies’ access to regulatory processes.

Some potential risk implications of response and engagement

As all risk managers know, intervention beyond the direct operations of a company may mitigate one set of risks, but can introduce new risks. This is the case in the highly politicised world of water – the following areas of risk are worth considering in any risk mitigation strategy:

- Interventions that are not aligned to local/river basin needs face the risk of being ignored or even opposed by stakeholders, with negative consequences for the company.
- Absence of key political or stakeholder engagement which exposes the initiative and the company to later accusations of “rail-roading”.
- Effective engagement requires skills and expertise on both sides and the lack of these in government or stakeholders jeopardises the ability to engage.
- Government and civil society perceptions around corporate influence on government in order to further their own interests to the disadvantage of other groups.
- Government abdication of responsibility for water functions to business, leaving the company with responsibility for a non-core function.
- Escalating resource requirements as engagement continues and becomes more complex.
- Exit challenges once effective engagement has achieved the corporate objectives, particularly where this has led to an intervention.

As all risk managers know, intervention beyond the direct operations of a company may mitigate one set of risks, but can introduce new risks.

These risks fall into two broad categories, namely the legitimacy of the engagement (in the case of the first four) and ongoing responsibilities associated with the engagement (in the case of the last three). The former can be dealt with by engaging in good faith from a shared risk perspective and entering into partnership with relevant NGOs, whereas the latter requires comprehensive strategic planning before embarking on any process of engagement. These risks are particularly relevant in developing countries, but similar issues may arise in managing risks in industrialised countries as well.

The role of insurance in managing water risk

As business leaders and risk managers become more aware of water risk, the need for effective risk management strategies involving insurance solutions is likely to increase. The insurance industry is beginning to respond to the challenge by developing risk assessment methods that take account of the location, nature and exposure of the water use being covered, together with broader corporate governance and management characteristics. The important recognition is that the water risk faced by a company represents a mix of environmental, political, operational and economic risks and risk managers will need to consider a range of insurance solutions from property and business interruption covers through to liability and reputational insurance. Because this is an emerging and dynamic area of insurance, the challenge is compounded by limited precedent. Despite this, insurance companies may want to explore the potential for offering tailored

As business leaders and risk managers become more aware of water risk, the need for effective risk management strategies involving insurance solutions is likely to increase.

products that assist companies with direct exposure to manage water-related risks to their operations, supply chains, markets or profits.

Strategies for companies to manage water risk

Primary and secondary productive sectors should measure, mitigate and market (three M's ©¹⁴)

These companies tend to face real business water risks, which can seldom be simply overcome by relocation. The first step is to understand the risk through assessment (measurement and metrics). This enables the company to focus its response through mitigation of the greatest physical, social or regulatory water risk areas – internally (operational and supply processes), locally (water management) or nationally (water policy). Finally, those facing reputational risk or positioning themselves as sector leaders need to effectively communicate market engagement activities. This is particularly relevant for companies involved in agricultural, food and beverage, textile, extractive (mining and oil), chemical and utility sectors.

Tertiary service sectors should identify, influence and invest (three I's ©¹⁵)

These companies have more flexibility in managing their transferred water-related risks. They may identify and select suppliers or clients according to their risk profile. Alternatively, they may induce or influence these suppliers to mitigate their water risks, or may set standards that suppliers must achieve. Finally, investment decisions will increasingly consider the risk associated with operations and supply chains supporting production. In fact, some service sectors will benefit from potential uncertainty and risk around water, for example by trading in water-dependent agricultural commodities. These approaches are particularly relevant for retail and financial service sectors.

¹⁴ Copyright Guy Pegram, Pegasys International

¹⁵ Copyright Guy Pegram, Pegasys International

Corporate perspectives on water risks and engagement

As a summary of these corporate perspectives on water risk, it is worth outlining areas of agreement among some of the companies leading in corporate engagement of water.

- **Increasing water scarcity is a reality** – water scarcity and water quality challenges are being experienced, and are subject to increasing attention from the corporate sector.
- **Greater role for corporates in the management of river basins** – water risks primarily lie outside a company's operations and supply chain and require addressing at a local or basin level.
- **Climate change plays a significant role in the focus on water** – the onset of climate change will increase primary and secondary water scarcity in a number of river basins, in particular by increasing the uncertainty around rainfall and river flows.
- **Water risk focus and expenditure has been resistant to the financial crisis** – ongoing corporate water initiatives have not been heavily impacted by the financial crisis.
- **Water initiatives are funded as part of a company's core business** – water risk is seen to pose operational risks and is therefore seen as part of its core business.

The areas of divergence include:

- **Assessment of water risk** – methods to measure water use, impacts and risks, and means by which to identify appropriate responses, in terms of footprint, life cycle and risk assessment metrics.
- **Optimal way to engage stakeholders and governments** – approaches to external engagement reflect the nature of risk and corporate resources available, ranging from direct local community engagement to multi-stakeholder platforms at river basin level.
- **Usefulness and longevity of global corporate initiatives** – the need for global initiatives, such as those led by the World Economic Forum, the UN Global Compact CEO Water Mandate and the World Business Council for Sustainable Development; and agreement on the future direction that they will take. This includes the need for disclosure and accreditation.

What this demonstrates is that corporate management of water risk will continue, but that currently the space it occupies is very dynamic. However, as the field matures over the next few years and businesses refine methods and approaches, greater consensus is likely to emerge about the appropriate means of assessing and responding to water risk.

The water risk faced by a company represents a mix of environmental, political, operational and economic risks and risk managers will need to consider a range of insurance solutions from property and business interruption covers through to liability and reputational insurance.

CONCLUSIONS

NEW PERSPECTIVES ON WATER FOR THE 21ST CENTURY

From the arguments and illustrations presented in this report, it is clear that water-related risk is emerging as an important corporate strategic issue. Furthermore, it appears that these risks are not going to go away and will likely increase over the next decade.

This is a new and dynamic field for companies and there remains a great deal of uncertainty about the most appropriate response to this risk. The water risks that companies experience vary according to their disparate operations and different supply chains. However, it is highly likely that, at some stage, most companies will face water risk of some type and will have to address and manage this risk. Innovative business leaders are proactively addressing this eventuality.

Companies cannot manage all of these water risks internally, nor can they manage risk alone. Managing these water risks requires action at a local/river basin level which will improve broader water management. This typically involves some degree of cooperation with stakeholders or government to improve water management, possibly facilitated by an independent third party.

This type of external intervention may raise a number of new risks for a company, including risk from engaging with new stakeholders, potential risk from increased transparency over water use and even the perception that companies are exercising “policy capture” over governments. In all cases, it is important to understand the nature and exposure to water risk and then to be considered and strategic about the response.

USEFUL CONTACTS AND REFERENCES

Alliance for Water Stewardship

www.allianceforwaterstewardship.org

Comprehensive Assessment of Water Management in Agriculture

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