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Mitigating Corporate Water Risk: Financial Market Tools and Supply Management Strategies

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ABSTRACT: A decision framework for business water-risk response is proposed that considers financial instruments and supply management strategies. Based on available and emergent programmes, companies in the agricultural, commodities, and energy sectors may choose to hedge against financial risks by purchasing futures contracts or insurance products. These strategies address financial impacts such as revenue protection due to scarcity and disruption of direct operations or in the supply chain, but they do not directly serve to maintain available supplies to continue production. In contrast, companies can undertake actions in the watershed to enhance supply reliability and/or they can reduce demand to mitigate risk. Intermediate strategies such as purchasing of water rights or water trading involving financial transactions change the allocation of water but do not reduce overall watershed demand or increase water supply. The financial services industry is playing an increasingly important role, by considering how water risks impact decision making on corporate growth and market valuation, corporate creditworthiness, and bond rating. Risk assessment informed by Conditional Value-at-Risk (CVaR) measures is described, and the role of the financial services industry is characterised. A corporate decision framework is discussed in the context of water resources management strategies under complex uncertainties.

KEYWORDS: Water-risk management, water scarcity, decision framework, water trading, water derivatives

CONTEXT

The issue of water scarcity has been recognised by the public health and environmental communities for decades, whereby declining groundwater, river flows, lake levels, and wetlands are limiting public access to clean water and creating stress on aquatic biologic systems (e.g. Postel and Richter, 2003;

Gleick et al., 2011). However, over the last decade the business community has come to recognise that this growing problem of water supply reliability can also create significant business risks across many industries (e.g. Orr et al., 2009; CDP, 2011; Ceres, 2011). These risks include physical risk, where the lack of available clean water may disrupt production; regulatory risks, where future regulatory or legal actions may limit access to water for use in production or supply chains; and reputational risks that may impact a company's brand identity (WWF UK and HSBC, 2009). Experts are predicting that the issues of water scarcity and uncertainty will worsen with population growth, increasing agricultural and energy demands and climate change.

The range of business sectors exposed to water-related risks includes food and agriculture, forestry, mining and the steel industry, shipping, water utilities, manufacturing, chemicals, pharmaceutical industry, and the energy sector as described in this paper. In food and agriculture industries, the availability of water and quality of water used in irrigation and production (from food to energy crops) are challenged because of depleted supplies, expanded agriculture, and increased use of irrigation. However, it is also exacerbated because of competitive water use by high-value industries such as energy production (de Fraiture et al., 2008). Clothing companies like Gap and Levi Strauss are realising how this resource, or its absence, can impact their bottom line (Morikawa et al., 2007). In 2011, cotton prices reached an all-time high due to massive output reductions brought about by drought and water shortages in Texas, India, Pakistan, and Brazil. The forestry industry is impacted by water-quality management issues (e.g. run-off and discharge to streams and lakes) and the availability of water for plantations as feedstocks and for production processes in operations like pulp and paper. Power utilities, especially those using once-through cooling, are faced with the question of when or if to invest in technologies that reduce water use to address stochastic uncertainty in the operational environment. Water shortages and other water risks such as elevated water temperature and biofouling result in an increased frequency of de-rating events (reduction in power production capacity) due to condenser back-pressure build-up, obstruction of cooling circulating water flow through condenser tubes, and/or insufficient cooling or steam generation. The challenge faced by utility managers is twofold: the frequency and severity of de-rating events in the future are unknown, and costs associated with each event are uncertain (Wolfe, 2008; Rice et al., 2012). In the beverage industry, controversies over water shortages in India impacted operations for The Coca-Cola Co. and PepsiCo bottlers, and many beverage companies, including Nestlé Waters, are facing strong opposition to the building of new bottling plants because of water supply concerns. Indeed, numerous industry sectors should expect decreased water allotments, shifts towards full-cost water pricing, and ever-more stringent water quality regulations.

In response, a growing number of protocols, tools, and decision-support frameworks are being developed and applied to assess corporate water practices and support development and implementation of sustainable water stewardship strategies. The key components of these 'water stewardship tools' are numeric and narrative techniques for characterising water consumption, impacts, and risks. There currently exist approximately two dozen such initiatives (UNEP, 2011; CGLI, 2012; WBCSD et al., 2012) with more under development. While many of the initiatives address multiple objectives, they can generally be grouped into four broad categories based on their major elements:

- Water use accounting tools
- Business risk assessment frameworks
- Reporting and disclosure protocols
- Standards and certification frameworks

Most initiatives include water accounting metrics to some extent, and developers typically describe the purpose of their accounting metrics to assess the uses, compare performance, or measure progress toward sustainability targets. The most common water accounting metric is the volume of water withdrawal, but many initiatives also focus on consumptive use. Some tools assess direct use in operations, whereas others also address supply chain water use. However, regardless of the volume of water used or consumed, the numbers by themselves do not reflect associated impact or risk because the local watershed context must also be considered.

Addressing the issue of local context, several new and emerging tools go beyond water use accounting to assess physical, regulatory, and/or reputational business risks. For example, Aqueduct (WRI, 2012) provides an interactive mapping tool to enable companies to quantify and map a range of water risks at a local scale worldwide. GEMI's Local Water Tool (GEMI, 2012) and the Water Risk Filter (WWF and DEG, 2011) not only help companies evaluate site-specific water impacts and risks, but also provide a framework to prioritise or select among water management actions at high-risk locations.

Reporting frameworks such as the Global Reporting Initiative and CDP Water Disclosure are primarily intended for information purposes for internal use or reporting to external stakeholders, and they are not specifically designed to help companies develop strategies for reducing risks. The Ceres Aqua Gauge (Ceres, 2011) defines leading practices such as stakeholder engagement to reduce water-related risks.

These new risk-assessment tools will help companies understand where in the supply chain their greatest water-related risks lie, and some offer ideas for response actions to mitigate risk in specific high-risk locations. Such actions may include measures to reduce and reuse water, engage with local stakeholders, and take action in local watersheds and communities to improve the sustainability of the resource (e.g. Ostrom et al., 1999). These are essential responses where appropriate, and should be part of a company's overall water strategy, given the various property right systems that are used to regulate common-pool resources (CPR). This paper discusses response actions from a corporate perspective, as opposed to a public policy perspective, and addresses the full spectrum of response actions. The integration of these corporate actions, and the overall value at a risk-driven decision framework, will be discussed in the context of water resources management policies.

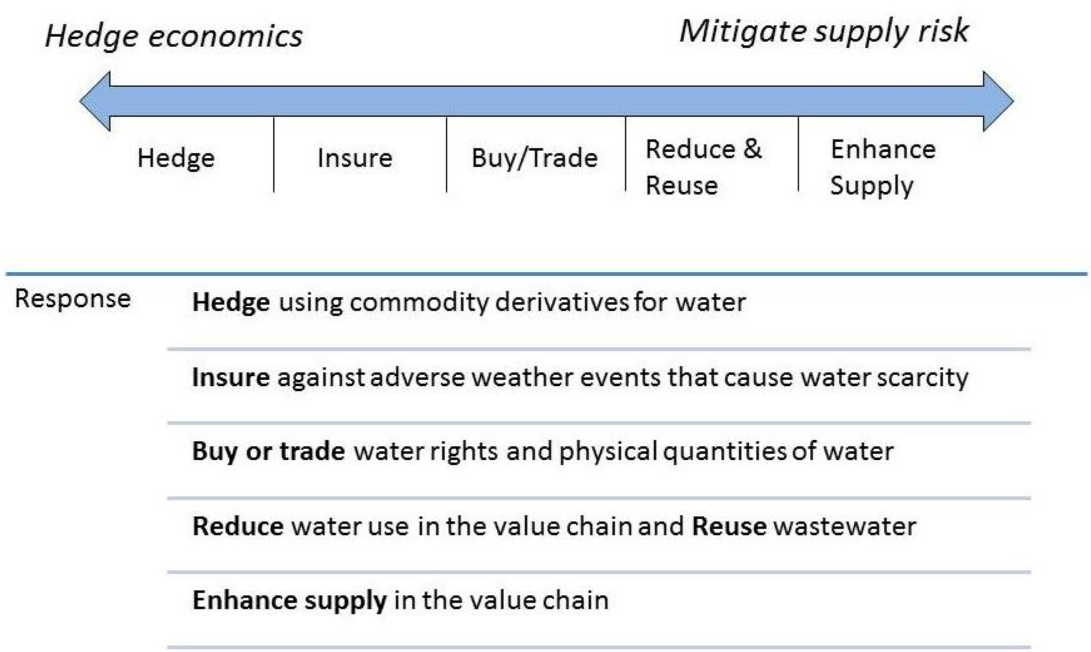
The focus in this paper is a corporate perspective towards water-risk mitigation related to water supply reliability in terms of the quantity of available water, rather than a discussion of public policy. The issue of supply reliability relates to over-allocation of available resources as well as year-to-year variability in hydrology and impacts of climate change. This paper also focuses on water quantity issues rather than on water quality impairments. This is not intended to minimise the importance of impaired water quality as a risk or the significance of water pollution as a global water problem.

WATER-RISK RESPONSE SPECTRUM

The opportunity cost from water risk across industry sectors has been evident for years, but it has only recently been explored across corporate value chains (e.g. Morrison et al., 2009). It is necessary to understand the vulnerability of supply chains to water risk to understand the economic impact and response or mitigation activities (Esty and Porter, 1998). Water footprints are a good starting point to understand use per unit product of economic output, and the distribution of water consumption across the value chain of impacted industry sectors. However, water footprint numbers by themselves do not help management to quantify risks. To understand risk response, it is important to consider how each segment of the entire value chain employs different water-risk mitigation strategies (e.g. Doherty and Smith, 1993; Everingham et al., 2002; Ceres, 2011). Even though responses to water risk are often considered in the context of infrastructure and capital investment in technology, business water-risk transfer through hedging, insurance, and other market instruments has received increasing attention in recent years (Jensen and Namazie, 2007). For example, given the increasing vulnerabilities of agricultural crop production to climate variability, the redistribution of rains with flooding and droughts has prompted interest in optimisation strategies between crop planting schedules and financial hedging strategies (e.g. Liu et al., 2008; AitSahlia et al., 2011). The available market instruments include various types of crop insurance programmes and futures contracts. Optimisation of planting strategies and financial hedges is driven by the desire to manage downside risk and maximise expected revenues.

Expanding from this example, Figure 1 depicts five categories of response actions that companies can undertake to mitigate risks in a continuum ranging from economic hedging mechanisms at the left to measures that a company may take to enhance water supplies at the right. The left side of the spectrum represents categories of action that purely address the risks of impacts on revenues or costs due to water scarcity. In financial terms, companies may address this by employing a number of market-based mechanisms such as investments in commodity futures or weather derivatives to financially hedge against physical water risks. There is no standard model for valuing weather derivatives because the asset is non-tradable. Therefore, the business valuation of a derivative is based on a utility curve of financial performance with respect to particular weather variables. Moving to the right, insurance tools can more directly address the impacts of scarcity on production. Examples might include weather and crop insurance which cover the economic impacts of drought, flooding, frost, and hail (e.g. yield-based insurance, revenue-based insurance, and catastrophic coverage offered by the Risk Management Agency of the US Department of Agriculture). While all of these mechanisms may address short-term financial losses when extreme events disrupt business opportunities or profit, they do not address the fundamental issue of water availability and, hence, economic productivity.

Figure 1. Corporate water risk response spectrum.



The right side of the spectrum depicts response actions by individual companies that are directed at reducing physical risks associated with disruption or shortages in water supply. Internal operational water use reduction, recycling, and/or water reuse can reduce demand to help ensure that supplies will be adequate to meet future needs, which has relevance to market positioning. At the far right are activities designed to enhance overall supply in a watershed or aquifer. They are externally focused and address sustainable water resources for local communities and nature, as well as for the company. In some cases, they may increase available supply. Companies may act individually or they may work with other stakeholders including governments to influence change on a watershed or regional scale. Working in the context of multi-stakeholder watershed plans is always preferred. In the very middle of the spectrum is the purchasing or trade of water rights. Such actions incorporate both economic and availability considerations to some degree, but they are primarily a mechanism to reallocate available water.

Each of the above categories is described in more depth below, starting at the left of Figure 1 and moving progressively to the right.

Derivatives/hedging

Until recently, companies have mostly relied on insurance for protection against unexpected weather conditions (e.g. revenue-based, yield-based, and catastrophic insurance). However, weather insurance generally provides protection only against catastrophic damage caused by high-risk, low-probability events such as extreme droughts, floods, or hurricanes. Weather derivatives, on the other hand, cover low-risk, high-probability events, and are a fairly recent option available to mitigate risk (Muller and Grandi, 2000). The first transaction in the weather derivatives market took place in 1997. There are a number of drivers behind the growth of the weather derivative market. Primary among these is the convergence of capital markets with insurance markets. Essentially, they are index-based products that quantify weather in terms of how parameters such as temperature or rainfall deviate from the monthly or seasonal average in a particular city or region, and trade these stochastic risks at market rates (Alatona et al., 2002; Cao and Wei, 2004). Companies may use weather derivatives to hedge against business risks that arise as a result of unusual weather. Hence, Cargill might decide to hedge against a growing season that forecasters expect to be drier than the historical average because its revenues would be affected as a result of poor crop yields.

As an example, the Chicago Mercantile Exchange (CME) offers weather derivatives that are standardised contracts traded publically on the open market. Each product, whether based on temperature or rainfall, is tied to an index. For example, summer weather is measured in terms of temperatures that exceed a base of 65 °F and referenced to a Cooling Degree Day (CDD) Index. Winter weather is measured in terms of how much temperatures are below 65°F and are referenced to a Heating Degree Day (HDD) Index. The CME offers temperature derivatives for US weekly, monthly, and seasonal weather as well as for monthly and seasonal weather for Australia, Europe, Asia-Pacific, and Canada. The final index values are determined using data provided by the National Climate Data Center (NCDC). Rainfall derivatives are currently more limited – the CME Rainfall Index is available for ten locations in the United States and the contract months are March through October.

In addition to the CME, there is also an over-the-counter (OTC) market for weather derivatives, where individualised agreements are privately negotiated between two parties. According to Environmental Finance (2012), the global weather derivatives market reached US$11.8 billion in 2010-11, an increase of 18% from 2009-10. There were 466,000 contracts traded on the CME, as well as 998 OTC contracts. Temperature contracts remain the most traded weather hedge, but there was growth in rainfall, snow, hurricane, and wind contracts. Moreover, weather derivatives activity outside North America and Europe has been on the rise. To date, utilities have been the largest end-users of weather derivatives. However, there are many other businesses for which weather has a major impact on revenues. It is anticipated, for example, that positions in agricultural commodities will be hedged with weather contracts more extensively than power and gas positions because of the long series of historical data available in the agricultural markets (Turvey, 2001; Vedenov and Barnett, 2004).

In terms of benefits and limitations, weather derivatives, specifically rainfall options, offer a company the opportunity to financially hedge against the changes in costs, the harm from reduced water supplies, or the disruption of supply chains. These tools provide reductions in financial risks but do not necessarily protect economic productivity. Agriculture is the most obvious and common application for rainfall derivatives, since unusually dry (or wet) growing seasons can have big impacts on agricultural productivity. This is particularly useful for a company that does not own the agricultural component of its value chain and therefore may not be able to insure its business operations against droughts or floods (Dishel, 2002). For example, a clothing manufacturer in the United States could theoretically purchase rainfall options for a region of India to protect itself against a poor cotton crop yield or higher water prices due to a drier than normal growing season. One major downside to trading weather derivatives is that weather risk is highly localised and cannot be predicted precisely and consistently (Odening et al., 2007). This uncertainty is partly offset by the fact that rainfall options are only offered as monthly contracts, so the effects of variable daily rainfall are somewhat muted. The second challenge is that pricing weather options requires a historical temperature or a rainfall database and application of statistical methods for fitting distribution functions to data. Defining an appropriate mean and standard deviation is the key challenge in simple-option pricing, given the challenge that climate is non-stationary (the relevant mean and standard deviation evolve with time).

Insurance

Recently, there has been increased interest in new forms of insurance to protect against weather volatility, most predominantly in the agricultural industry. Traditionally, this insurance has taken the form of crop insurance, offered through national governments. Weather insurance, specifically rainfall insurance, is a specific type of weather insurance that pays out based on the rainfall recorded for a specific location (Barnett and Mahul, 2007; Breustedt et al., 2008).

Unlike traditional crop insurance, rainfall-based insurance is grid-specific, meaning local trends and values are the basis for pricing risk. In the United States the 'grid' used to price risk is 12 miles by 12 miles (Skees et al., 1997; Maldonado, 2011). Usually, this grid is the basis for a rainfall-based insurance, whereby insurance is priced and offered based on deviations from the mean of historical data for the region. Rainfall-based index insurance can help offset the potential financial risks associated with water scarcity and provides a useful price signal to policy makers, water authorities, and economic actors, compared to the actual price of water on the market. If a company or other economic actor is faced with less severe water-scarcity risk, rainfall insurance could provide an effective method for mitigating cost increases in supply chains or direct economic costs associated with water scarcity. Rainfall-based insurance is grid-specific, and the rates and trigger points are determined by the insurance policy written. Generally, the premium and insured value are commensurate with the economic value of the product. For example, farmers of high-value crops pay premiums on the order of US$25,000 to insure US$200,000 worth of loss, whereas biofuel companies pay multiples of this premium to cover US$2.5 million (Environmental Finance, 2012).

Since 2007, the US Department of Agriculture Risk Management Agency (RMA) has been testing a pilot project called Rainfall Index insurance (RI-PRF), which is designed to insure against losses due to low rainfall measured as declines in the rainfall index within a geographic grid. The United States has approximately 588 million acres of pasture and rangeland. At US$20 per acre, this equals a US$11.8B potential market for rainfall insurance. Currently, the programme is in a pilot stage with multiple projects piloted in the US. In New South Wales (Australia), rainfall index insurance is used as a proxy for irrigation levels at a local dam (Zeuli and Skees, 2008). Over 70% of the irrigation networks in North South Wales water supply were positively correlated to the amount of rainfall the area received. This points to the possibility of creating rainfall-based insurance to help local farmers and other users to mitigate their water risk. Water authorities and decision makers now have more transparency when setting water prices as a forward-looking pricing mechanism. Farmers will have additional information to make water-saving irrigation investments since the rainfall-based insurance markets give a more accurate view on future water prices.

Over the past 10 years, governmental institutions such as the World Bank, reinsurance companies, and NGOs have become more active participants in rainfall insurance schemes, usually on a micro-scale (Gine et al., 2008). Countries where case studies have been initiated include India, Malawi, Morocco, and Nicaragua. However, the pilot programmes are region-specific, and due to the large amount of data needed to make accurate rainfall predictions, large infrastructural investments are necessary. Unless a large-scale effort is undertaken, it is unlikely that rainfall-based index insurance will be available soon outside developed countries.

Although rainfall index insurance is an effective method for mitigating risk associated with volatile rainfall patterns, it has limitations as a sole risk-mitigation strategy. Overall, rainfall index insurance only mitigates the economic consequences and does not provide a long-term solution to water scarcity. Secondly, there are execution risks with rainfall insurance such as the direct correlation between economic risk and rainfall; farmers may underestimate the risk associated with catastrophic rainfall events, and the accuracy of a specific policy to the actual geographical area a farmer needs covered. Lastly, selling multi-year contracts will be difficult, because weather phenomena such as the El Nino Southern Oscillation (ENSO) dramatically affect rainfall predictions.

Water trading and water rights

Water trading, which reallocates available water supplies, falls in between actions that are economic hedges and actions that affect supply and demand on the risk-response spectrum. Water trading refers to the act of buying, selling, or trading water rights, which are legal entitlements to water. The main intent of water-trading mechanisms is to promote more efficient water allocation among competing consumptive users by establishing a market price for water (Easter et al., 1999). As a result, users who place a high value on water are able to purchase water rights from those users who value it less. In practice, agricultural users are usually the sellers and municipal and industrial users are usually the buyers. This occurs because farmers typically receive generous water rights, and pay less for water than municipal and industrial users who are able to significantly reduce their own water consumption by employing water conservation technology and best practices (Brooks and Harris, 2008).

There are several different types of trades that may occur between a buyer and a seller, depending on the specific rules and regulations of the water market in question. While trading forums are relatively rare, two of the more common ones are water access entitlement trades and water allocation trades. In the former, the seller permanently transfers or temporarily leases all or part of his/her water access rights to the buyer. In the latter, the seller transfers all or part of his/her annual water allocation to the buyer for a specified term that may range from a few months to more than one year. There are also instances where cities have purchased callable water options, which allow them to lease water under specified drought conditions. There has been an increasing focus by water managers on demand-side strategies to deal with scarcity, and improve water use efficiency and productivity (Bjornlund, 2003). Chong and Sunding (2006) argue that trading helps equalise the marginal prices faced by various water users, thereby providing information about the value of water in alternative uses and creating compatible incentives, but that putting water markets into practice introduces real-world complications of transaction costs and third-party externalities (Archibald and Renwick, 1997).

The valuation of trades is region- and sector-specific; for example, trades in the Murray-Darling basin (MDB) in Australia (a cap-and-trade scheme), which supports industries ranging from farming to mining, have recently peaked during the midst of a 10-year drought in the range of AUS\$250-1000/m^3, whereas in the Colorado basin water rights (not capped) prices differ between the Front Range and the west basin, ranging from US\$0.5-10/m^3 (Brookshire et al., 2004; Brooks and Harris, 2008). Even when excessive costs for water rights trades prevail (e.g. California), there is still significant potential for the market reallocation of water, using annual spot markets for times of scarcity and option markets for longer-term contracts (Howitt, 1998).

A case example, the MDB in Australia is home to one of the world's most well-developed water-trading schemes (Turral et al., 2004). Participants in the MDB water market include farmers, water utilities, industry, and environmental groups. Each state and territorial government maintains responsibility for the legislative and administrative arrangements for water rights and water trading. This includes maintaining a water register to record water access entitlements, including ownership details and transactions. Users are able to buy and sell both water access entitlements and water allocations, and access to relevant market information is readily available on the web. According to a 2010 report by the Australian National Water Commission, water allocation trading in the southern MDB increased by 58%, from 1098 gigalitres (GL) in 2007-08 to 1,739 GL in 2008-09. In the same period, water entitlement trading increased by 116% from 500 to 1,080 GL. Water trading in the southern MDB in 2008-09 is estimated to have increased Australia's GDP by over US$200 million (Nikolakis et al., 2010).

Water trading allows companies to secure water that they require for daily operations. Corporations may benefit from a water-trading scheme in regions where there is competition for scarce water resources due to increasing demand or dwindling supply. Water is often not allocated efficiently between agricultural, municipal, and industrial users. For example, the Australian Bureau of Statistics estimated the Gross Value Added (GVA) per mega liter (ML) of water used for several different industries and found that mining and manufacturing had a GVA/ML of more than AUS$80,000 (US$83,660), while agriculture had a GVA/ML that ranged from approximately AUS$3,250 (US$3400) for vegetables to about AUS$100 (US$105) for rice. This illustrates the fact that not all uses of water are equally productive and that efficient water allocation can have a significant economic impact (Roberts et al., 2006). Another benefit of water-trading schemes is that they incentivize water efficiency because water users receive the opportunity to profit from any water that they do not use, either by selling a fraction of their water rights or by leasing out their unused annual water allocations. In the MDB, water trading was found to be one of the key factors influencing investment in irrigated agriculture infrastructure (Nikolakis et al., 2010).

There are a number of risks and limitations inherent in water trading. First, in order for water trading to be a viable option there needs to be certainty over water rights and a legal institution in place to enforce trades such that transaction costs are kept relatively low. This is often absent in less-developed countries where there is more corruption and less recourse available in the case of unjust trades. Furthermore, water markets need to account for the social and environmental effects of water trading. A change in the timing and location of water use may have unforeseen consequences on both the environment and on downstream users. These externalities are complex and difficult to incorporate into the market price of water.

In addition, market participants need to be in geographical proximity (or have access to the same water source) because transporting large quantities of water is prohibitively expensive. This means that water trading is most effective on a regional level, which may limit the number of participants as well as the amount of water available for trade. Furthermore, there needs to be a reason for both public and private players to want to have access to a market for trading water rights. In regions where one or two major entities dominate water withdrawals and the government has no leverage, there is little chance of a market solution being implemented. Finally, and most importantly, water trading does not offer absolute protection against water risk. For example, in the case of an extreme drought, water allocations may be reduced or there may simply not be enough water available to exercise purchased water rights. Hence, there can be economic or production threats due to water scarcity that must be addressed by alternative actions.

Reduce, recycle, and reuse

Reduce, recycle, and reuse projects focus on reducing demand by individual companies. Improving water efficiency and wastewater quality in direct operations should be the highest priority where it is economically feasible, particularly where company-related risk is determined to be high (WWF Germany and DEG, 2011). Actions that reduce usage may include increased efficiency, conservation, and improved operations; changing operations to recycle the use of water; or taking used waters and reusing them for other purposes with or without treatment. These may be immediate actions or plans for future actions when more supply is needed.

Many corporations are engaged in proactive water stewardship programmes focused on improved water use practices in their own operations, where they have greatest control. However, indirect water use in the supply chain often represents the largest proportion of water use, as demonstrated through water footprint assessments for agriculturally derived products conducted by Coca-Cola (TNC and TCCC, 2010), SABMiller and WWF (2009) and others. These companies and others recognise the associated risks and are beginning to work with suppliers of raw materials to improve practices. For example, numerous companies in the food and beverage and energy sectors have formed the multi-stakeholder organisation Bonsucro to develop a global metric standard directed at improving sugar-cane production and downstream sugar processing (Bonsucro, 2011). Companies are collaborating with non-governmental organisations such as World Wildlife Fund and The Nature Conservancy on many of these efforts. As an example, Holcim (supplier of cement and aggregates) is working with the International Union for Conservation of Nature (IUCN) to develop a water management strategy that will include tools for measuring and mitigating water risk in company operations (IUCN, 2012).

In direct operations, 'reduce' strategies may include actions such as repair and replacement to fix and prevent leaks, and converting to processes that use less water. Examples of water-saving strategies in the thermo-electric power industry include air, and air/water hybrid cooling (EPRI, 2010). In the food and beverage sector, many companies save water by using innovative methods for cleaning bottles. For example, to meet the company's goal of improving water-use efficiency by 20% per unit of production by 2015, PepsiCo is employing a number of technological improvements including cleaning new Gatorade bottles with purified air instead of water (PepsiCo, 2012). Improved efficiencies have been demonstrated in the industrial manufacturing sector as well. For example, Ford Motor Company reported that it reduced its global water use by 62%, or 10.5 billion gallons, through a combination of leak repairs, reuse of treated wastewater, improved floor cleaning procedures, and numerous other operational and equipment changes (FMC, 2011).

'Recycle' strategies are directed at internal recycling of water and improved wastewater treatment. While internal recycling may or may not reduce overall water consumption, it reduces the volume of water withdrawn from the source. For example, in the electric power sector, companies can switch to closed-loop cooling instead of once-through cooling to reduce their water risks. The term 'recycle' is sometimes also used to refer to treatment of wastewater to appropriate standards, thereby ensuring that water returned to the environment is of sufficient quality so that other uses are not impaired (TCCC, 2012). However, this type of action has no direct impact on reducing business risks related to water availability, even though it may politically position the company better in terms of getting its needed allocation and does represent good corporate citizenship.

'Reuse' strategies involve reusing wastewater for multiple purposes, or using wastewater from other companies as a supply source instead of groundwater or surface water. Numerous communities from Singapore to Tucson, Arizona, in the US make use of reclaimed municipal wastewater effluent for beneficial purposes. Reuse of treated process water can have multiple benefits for a company, including a reduced perception of the company as a large water user.

Reduce, recycle, and reuse generally decrease the demand for water and thereby reduce water-related risks for a company. When actions are implemented in a company's direct operations, they are fully under the company's control, the cost/benefits from the investment can be evaluated, and companies have reasonable assurance of the outcomes. A side benefit may be cost savings due to reduced water use. However, reducing demand does not alone ensure that supply will meet demand, and companies must often look beyond their 'four walls' and consider other strategies along the water-risk response spectrum that are external to their own operations. In addition, some reuse and recycle processes may create unintended challenges due to concentration of pollutants. Practices such as recycling of cooling waters in the power sector result in a reduction in the volume of water withdrawal, thereby reducing risks, but more water is consumed compared to once-through cooling. This may lead to watershed complexities or even limits on withdrawals.

Enhance supply

At the right end of the response spectrum are actions that serve to protect and enhance the water supply for ecosystem functions, community use, and business operations. Water is a shared resource, and even the most efficient operation may be adversely impacted by external events such as overuse by others, droughts, spills, new regulations, and bad press. The focus of this paper is on actions that individual companies may implement, recognising that engagement with local governments and other stakeholders is becoming increasingly important as competing demands for water increase (Babel et al., 2005). Such engagement contributes to improved management of the resource and, in some cases, supports infrastructural investments to increase water yields.

Some leading companies are partnering with local organisations to undertake projects outside their operations, to protect and improve source waters and ensure the sustainability of supply for all users. For example, The Coca-Cola Company has undertaken hundreds of projects under an umbrella of what the company calls 'replenish'. In 2007, the company committed to "replenish the water used in our finished beverages by participating in locally relevant projects that support communities and nature, and to meet and maintain this goal by 2020" (TCCC, 2012). Many replenish projects of The Coca-Cola Company are directed at conservation, community water availability, and/or restoration and enhancement of water quantity and/or water quality. The term has no standardised definition but has been used in other contexts with the same general meaning.

Activities in the 'enhance supply' category that may be implemented by an individual company include a wide range of watershed improvements that may improve the availability of overall water supply in a watershed or aquifer. These investments by companies may focus on direct operations, supply chain water uses or unrelated activities in the watershed that enhance supply. These actions can be grouped into the following categories (Larson and Richter, 2009):

- Agricultural improvements that reduce water impacts through conservation practices.
- Land cover improvements such as re-vegetation and land conservation that reduce impacts from run-off.
- Surface and groundwater quantity management to improve sustainability of supply (e.g. redesign dam operations, floodplain reconnection, removal of invasive species, rainwater harvesting, and aquifer recharge).
- Water conservation and leak repair to improve sustainability of supply.
- Community wastewater treatment to reduce pollution.

The benefits from watershed projects can be quantified by evaluating the change in hydrology of a system. As an example, activities such as reforestation projects can increase infiltration and groundwater recharge, and this volume can be estimated. In the context of corporate risk, the focus is on increasing or stabilising supplies. However, it is recognised that many watershed activities are undertaken to return modified land uses towards a more naturalised state, which can offer environmental benefits and, in many cases, corporate risk reduction. Some actions such as rainfall harvesting are not necessarily 'natural' but can increase recharge and may be beneficial to enhancing supplies and reducing risks.

Jain Irrigation Systems in India provides an example of a company that has made a commitment to enhancing supply in its value chain. Jain is one of the world's largest producers of dehydrated onions, and the company recognises the risks of water scarcity in its agricultural supply chain, as overexploitation has led to rapidly declining water tables in aquifers used for irrigation. Jain's response strategy included encouraging rainfall harvesting and aquifer recharge, providing farmers with training on best practices including drip irrigation technology, and establishment of a water users' dialogue in the local river basin (Larson et al., 2010).

Some companies undertake activities to improve water access for communities in regions where safe drinking water is lacking, and such actions may be grouped with other supply enhancement efforts. As an example, Diageo reports that through its 'Water of Life' initiative the company has provided access to clean water to 4 million people in Africa since 2007, and is striving to provide access to another million more people every year until 2015 (Diageo, 2010). Water access projects may not reduce competing demands for water, but they do create positive stakeholder support and represent good corporate community commitment. By engaging in these types of projects, companies gain a better understanding of the local issues and needs, and have an opportunity to contribute to improved resource management and fair allocation of available water.

Corporate-funded watershed activities and water access projects are generally viewed favourably by communities, governments, and environmental advocates, because the intent is to improve and sustain water supplies for all users. These activities provide a means for companies to engage with stakeholders and enhance their corporate reputation as giving back to a community and helping to protect and sustain water as a common-pool resource (CPR). Ostrom et al. (1999) argue that: "solving CPR problems involves two distinct elements: restricting access and creating incentives… for users to invest in the resource instead of overexploiting it". The authors further conclude that "the broader economic setting also affects the level and distribution of gains and costs of organising the management of CPRs". When the actions are implemented in the watersheds where the company operates, they can help ensure the availability of water for business operations and protect financial interests.

However, these projects have their challenges and limitations. Most significantly, it is not always easy to identify suitable projects in the watershed where business operations are located. Identifying projects that generate significant benefit can be challenging enough, but often there are logistical, political, and economic challenges in implementing the projects. In addition, watershed projects may be inadequate to sustain adequate water supplies in scarce regions or during droughts, and do not ensure that public perception or regulatory action may still limit or prevent access to adequate supplies (EPRI, 2008). Finally, these projects increase the visibility of the business units, and may be viewed by some as 'greenwashing' to mask or offset the 'negative' impacts of business operations.

Engagement with other stakeholders in the watershed is an essential ongoing activity to support watershed planning and enhance supply reliability. Given the confluence of emerging business water risks impacting the bottom line of operations, and the need for equitable distribution of a common-pool resource like water, new cost-effective water resource management strategies and water allocation strategies are being proposed that explicitly consider the economic value-at-risk (e.g. Webby et al., 2007; Yum et al., 2009; Shao et al., 2011). Allocation planning is an important component of managing water uses, but the process is quite intricate, since balancing the water demands of competing users, such as the public, industry, and agriculture, is not an easy task. The problem is further complicated by the uncertainties that may be associated with almost every component of a water allocation system. Such uncertainties may arise from water quantity promised to various users, available amounts of water resources, water demand of different users, economic benefit from water consumption, and economic penalties from water shortage (opportunity cost). The tension between corporate and public optimisation approaches leads to difficulties for water managers or local authorities in generating cost-effective allocation plans, as alluded to earlier (Ostrom et al., 1999).

The next section focuses on the interplay between the emerging corporate decisions involved in downward water-risk management, and the due-diligence response of the financial services industry to assess operational, credit, and market risks. A conceptual framework for developing a response strategy is introduced and discussed.

RISK-RESPONSE DECISION FRAMEWORK

A company's water use may exacerbate the water risk that it faces by depleting a watershed that the company relies on for sustained operations. Therefore, companies must take measures to respond to water risk. Corporate responses to water-related risk range from purely financial strategies, to actions that reduce demand or increase supply, and usually include a mix of these actions. Figure 2 represents a decision framework for analysing the consequences of water scarcity and developing a response strategy. The framework outlines the types of information that should be incorporated when making a decision to effectively deal with water-scarcity issues, and extends decision-making strategies for revenue maximisation already considered in the agriculture sector (e.g. Liu et al., 2008; AitSahlia et al., 2011). The information needed to make decisions regarding water scarcity remains limited and complex; hence, the course of action favoured to address business water risk is conditional on the risk profile of the user. This framework provides a guide to help companies make strategic decisions to deal with water scarcity risk and has been implemented in various forms across multiple sectors, ranging from food and beverage to energy.

Figure 2. Water risk-response decision framework for businesses.

	Identify	Evaluate	Respond
Objective	**Identify water-scarcity risks**	**Determine the value at risk**	**Select a strategic risk-mitigation response**
Criteria	• **Physical risk** water use in operations • **Regulatory risk** local water pricing policy • **Reputational risk** impact of water use on the local community	• **Likelihood of risk** based on watershed data, climate trends and other indicators • **Magnitude of impact** economic loss suffered	• **Cost** of implementation • **Effectiveness** how much risk is negated • **Feasibility** (difficulty) • **Time** implementation timeline for response

The first step is to identify what risks may materialise as a result of water scarcity. There are many different risk taxonomies used in the field of risk management. Here, we chose to use one common scheme that categorises risks as physical, regulatory, or reputational. Physical risks are those posed by actual water scarcity and can be ascertained by looking at the water footprint of a company's operations. When examining water use, it is critical to understand when and where the water is withdrawn. Unlike greenhouse gas emissions, which have the same impacts regardless of where the emissions are generated, the absolute volume of water used is often less important than the timing and location of use. For example, one gallon of water used in an arid urban region poses a greater physical risk than a gallon used in a wet rural region because the uncertainty of the water supply in the future is much greater. Consequently, companies need to examine their water footprint data and identify whether there are any physical water-risk hot spots in their value chain.

Companies must also consider any regulatory and reputational risks posed by water scarcity. For example, water pricing impacts a company's bottom line if it pays for water for its operations. If a company operates in a water-scarce region, it may face the risk of increasing water prices, sometimes drastically and without warning. Similarly, companies need to be aware of other regulatory considerations, such as limits on water withdrawals. In terms of reputational risk, companies have to understand how their water use impacts the environment and local communities. For example, the United Nations' declaration of water as a basic human right has made it more important than ever for companies to be aware of their water withdrawal in less-developed regions, where many people survive on less than the recommended daily allowance of clean water.

The outcome of this first step should be a list of physical, regulatory, and reputational risks posed by water scarcity to a company's operations, specific to individual geographic locations.

The second step is to evaluate the operational, market, and credit risks associated with the water-constrained assets, and to arrive at a conditional value at risk that states the extent of the risk in monetary terms. Conditional value at risk is a variant of the popular value at risk (VaR) financial metric and takes into account both the likelihood and magnitude of a loss (Liu et al., 2008). The likelihood of a risk can be determined by examining watershed data such as the Aqueduct Water Risk Atlas developed by the World Resources Institute and the Water Risk Filter (WWF and DEG, 2011), and by analysing climate data for the region to understand projections for supply and demand. The magnitude of a loss must be estimated based on the effects that it would have on the company's operations.

There are many examples of the economic loss suffered by companies as a result of water scarcity. This loss can arise from disruption to the supply chain or from increased costs. For example, in 2011 cotton prices reached an all-time high due to massive output reductions brought about by drought and water shortages in Texas, India, Pakistan, and Brazil, prompting Gap to cut its annual profit forecast by 22%. This, in turn, resulted in a US$4 decline in its stock value. Both Gap and Levi Strauss raised costs of their products by 10 to 15%, which resulted in a decrease in sales. In the case of power production, the total cost of derating events at a 7mWh plant in 2007 in North Carolina ranged from US$8 to 32 per mWh, increasing to US$18 to 36 per mWh in 2008. This economic assessment, the second step, must include an analysis of the three types of risks (physical, reputational, regulatory) introduced earlier. One must also determine if the risk needs to be mitigated from purely financial-risk considerations, or whether there is a need to assure continued productivity and address the long-term return-on-assets, a market risk measure. This will guide the selection of actions along the response spectrum.

The outcome of the second step should be a monetary estimate for the value at risk for each specific risk. Once again, this should be done on a site-by-site basis. For example, the value at risk for water scarcity at a site in India should be determined separately from that for a site in China. This provides a company with much greater flexibility when it comes to formulating a risk-response strategy.

The final step is to identify a risk-mitigation response. Depending on the type of water risk the company is exposed to, the response may be operational (e.g. investment in capital infrastructure) or via market instruments. As illustrated earlier, the mix of water efficiency strategies and market-based options depends on the industrial sector and the risk context. As examples, farming industries, which are impacted by physical risks, often use market instruments, whereas companies that use agricultural products as part of a supply chain (e.g. Coca-Cola, PepsiCo, SABMiller, Nike) may invest in replenishment and reuse/recycle technologies in part to address supply reliability and because they may also face reputational risks. The energy industry, which faces physical and regulatory risks, will tend to hedge its water risk or trade/buy water rights, rather than invest in capital outlay, unless specific regional situations (e.g. South-West power plants) dictate otherwise. Some pulp and paper companies, in the face of regulatory risk, have invested in watershed management and capital infrastructure.

The third step analyses the impact of the risk-mitigation strategy on the corporate bottom line. Does the capital investment provide a sustainable financial return, and/or does it impact environmental liabilities? Decreasing water use and impacts in direct operations and across a company's value chain can reduce costs for water use and wastewater discharge, as well as the corresponding energy costs associated with heating or pumping that water. Integrated approaches to better water and energy management have allowed companies such as IBM to achieve savings of US$3 million while increasing output by 33% at a single plant. This included a 27% reduction in water purchases, almost US$1 million in water treatment savings, and US$1.5 million in energy savings, without incurring any capital costs. Proctor and Gamble's Fabric Care and Home Care segment had seen a 10% increase in net sales growth as a result of switching its liquid detergents to a compact form. Hence, various industries will respond as a function of the type of risk, the opportunity cost it represents, and the implied rewards in terms of capital efficiency (returns). One additional factor to consider is the time required to implement a specific risk-response. For example, a severe drought may require a company to take immediate action to reduce its water use through investments in water technology or risk a decline in production.

To illustrate a generic water-risk mitigation strategy (Figure 3), we assumed a projected economic loss of US$200,000. Lower cost options such as hedging, insurance, or reduce/reuse strategies would be favoured, provided they can address a significant portion of the economic loss (effectiveness), and are easy to implement (feasibility). For example, insurance presents a relatively low-cost risk-reduction option for, say, agricultural yield that would be favoured if drought or irrigation allocations may constrain available water for crops. However, since only 35% of the economic loss would be covered, it is likely that the operation will supplement this mitigation option using a hedging strategy. If the corporate decision is to deploy physical infrastructure to reduce uses, corporations will generally conduct a net present value analysis (NPV) or a real options analysis (ROA) to decide on the investment (Rice et al., 2012).

Figure 3. Example water-risk mitigation strategy for irrigation risk.

	Hedge	Insure	Buy/Trade	Reduce & Reuse	Enhance Supply
Cost	$40K	$55K	$110K	$65K	$80K
Effectiveness	20%	35%	65%	45%	50%
Feasibility	Easy	Easy	Difficult	Moderate	Difficult

- **Cost** is how much money would be required to implement the response.
- **Effectiveness** is the % of the total projected economic loss from water scarcity addressed by the response.
- **Feasibility** is how difficult it would be to implement the response.

Hence, when the shortfall in water and the resultant economic value at risk (loss of return on assets) are more severe, the company should pursue a more aggressive mitigation strategy. However, if the shortfall is relatively small and the value at risk is relatively small, a hedging strategy would be more appropriate. The difficulty lies when there is no clear answer, and a company will sometimes be forced to pursue multiple strategies. Often, a multi-pronged approach comprising financial hedging and other strategies will be most effective, as has been illustrated for cotton farming (Liu et al., 2008), depending on the risk exposure the business is willing to take on. For example, if reputational risk is significant, then engaging with other stakeholders will be important; however, the financial risk will still be present and could be best dealt with through hedging strategies. Increasingly, proactive public corporations will disclose water-risk mitigation strategies through their annual 10K reports, and through voluntary sustainability reporting (e.g. CDP Water Disclosure reports). Examples of water-risk management strategies by various industry sectors are shown in table 1.

Table 1. Example corporate water risk response strategies.

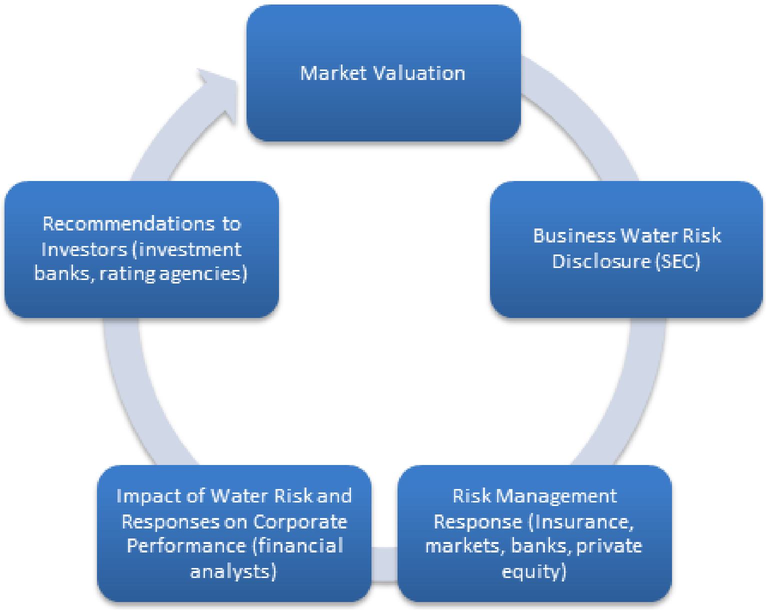
Industry sector	Industry sector or segment	Response action taken
Power	Hydropower	Insurance
	Natural gas	Trading
	Coal	Reduce water use
Beverage	Bottling	Replenish
Clothing	Farmers, manufacturing	Reduce/reuse (operational efficiency)
Pharmaceutical	Manufacturing	Reduce/reuse (membrane filtration)
Agriculture	Commodities	Hedging (weather derivatives)
		Insurance, futures

ROLE OF THE FINANCIAL SERVICES INDUSTRY

As indicated above, businesses have many options to reduce risks related to water. However, their decision-making process in selecting actions is not entirely controlled by internal factors, but is also influenced by the financial services sector. From due diligence influencing credit and market-risk assessment to bond ratings and securitisation of new financial products, the financial services industry is capitalising on this new opportunity. The industry seeks to leverage its know-how in responsible investment strategies and from its assessment of corporate Environmental, Social, and Governance (ESG) practices to quantitatively understand risk and drive risk-management strategies for sustainability (e.g. Reinhard, 1999). A decade ago, the 'cost of sustainability' question was pursued in the context of corporate investments to pursue a 'beyond compliance' strategy. Today consideration of corporate sustainability has moved to include the broader financial services sector beyond lending, insurance, and project finance (Jensen and Namazie, 2007). Market instruments and institutions, as well as the insurance industry, are increasingly part of the sustainability value chain. The nascent climate and water disclosure guidance by the Securities and Exchange Commission (SEC) to inform investors of risks and mitigation strategies now fully closes the loop on market drivers for sustainability (Aerts et al., 2008).

The disclosures are an extension of the US Sarbanes-Oxley Act (2002) that was enacted to ensure corporate financial transparency to protect and inform investors and restore public confidence in the securities markets. Inasmuch as water and climate risk impact corporate performance, the (institutional) investor is increasingly informed of not only the type and magnitude of water risk impacting the company, but also what the risk management strategy will be to counter these current or future risks. So where private investors (particularly on the technology-based risk strategies), lenders, and risk transfer (insurance and hedging) actors are important in the response strategy, it is independent analysts (e.g. Bloomberg NEF, investment banks) that study and interpret the corporate SEC-required filings for the impact of risk and response on corporate performance. Investment banks and ratings agencies will not only include ESG assessments in their corporate due diligence, but also issue recommendations on corporate performance and investment risk, as well as on the potential impact of environmental risk on corporate bond rating or credit worthiness. In turn, these recommendations affect stock prices and thus market valuation of the company (figure 4).

Figure 4. Impact of risk disclosures on corporate financial and market risks.



Beyond disclosures, financial institutions will use risk appraisal procedures specific to the type of transaction involved in risk mitigation, such as equity investment, loan, or bond issue. The outcome depends upon numerous factors including the size of the transaction, the nature of the project, whether the sector is regulated, and whether the project takes the form of a partnership between public and private sectors. When innovative technologies are considered as part of the solution (financed by venture capital or private equity), the investor may play an extensive role advising management on the design of the project and hence strategies to reduce risk. In the case of lending to small and medium enterprises (SME), banks may encourage their clients to use water-efficient technologies and practices by offering preferential lending terms. In a larger-scale corporate finance deal, lenders may require companies to carry out 'water due diligence' or to quantify the risks of water availability restrictions on financial performance (Jensen and Namazie, 2007).

In 2006, the financial services industry developed a benchmark for determining, assessing, and managing social and environmental risk in project financing through the Equator Principles (Wright and Rwabizambuga, 2006). These principles apply to all new project financing globally with total capital costs of US$10 million or more, and across all industrial sectors. The underwriters focused on project financing covering expansion or upgrading of an existing facility where changes in scale or scope may create significant environmental and/or social impacts, or significantly change the nature or degree of an existing impact. Hence, the principles impact the loan covenants or result in differential lending rates for risky projects (Scholtens and Dam, 2007; Macve and Chen, 2010).

Financial service entities are also very active in funding water assessment, business practice reviews, and water disclosure frameworks (UNEP, 2011). These frameworks provide businesses and the financial sector with useful information on company risks in the context of water, as well as an evaluation of the effectiveness of their practices to reduce risks. Hence, the financial services industry is both in a leading and a responsive mode to corporate water-risk management.

CONCLUSIONS

Reliability of water supply associated with water scarcity and other external factors is emerging as one of the defining challenges of the 21st century. It is posing threats not only to public and ecological health but also significant business risks for companies. Recognising these problems and risks, companies and the financial service sector are devising tools and strategies to understand, disclose, and reduce water-related risks. This paper has provided an overview of the range of strategies, the roles companies can undertake, and the role financial service sectors play in risk management and mitigation.

Water risks are inherently a local issue with company-, plant-, industry-, and area-specific issues and strategies. Hence, it is difficult to develop generalised approaches to mitigate risk. More so, it is difficult for companies to develop simple corporate-wide strategies or for portfolio managers to make easy assessments of company risks over large numbers of holdings. The overview presented in this paper serves to begin to provide a framework for making these assessments and devising strategies.

The framework presented in this paper provides a response spectrum for reducing risk with examples provided and comments on benefits and limitations, from the company's perspective. Implicit in this perspective is the optimisation for downside risk management (operational, reputational, and regulatory) from water. It thus represents an emerging conceptual framework, which has seen some degree of validation in selected industrial sectors and in the financial services industry, on how to develop a strategy and select among the response options. Clearly, the response spectrum is influenced by the prevailing water-allocation strategies for public and industrial use in the impacted watershed or basin (Ostrom et al., 1999). Cost-effective water allocation strategies tend to maximise the economic benefit in the region over the planning horizon. Based on the local policies of water resources management, a target amount of water can be promised to each user sector in the region. If the promised amount of water is delivered on time, it will bring net benefits to the system; otherwise, penalties of economic loss will be incurred as a result (Webby et al., 2007; Shao et al., 2011), and investment decisions need to be made to support ongoing corporate activities.

Despite the recognition of opportunity cost in water allocation strategies, rigorous financial metrics related to water risks and mitigation strategies are still lacking. The result is that often one-off (single stage) decisions are made to choose response strategies, for example based on limited knowledge from due diligence questions pertaining to water-risk exposures that influence debt rating and market risk. There is a need for both decision-making tools that explicitly link water use and allocation to opportunity cost, and the way risk reduction strategies can be explicitly incorporated into econometric value chain analysis. Indeed, a recent MSCI roundtable on responsible investment (RI) alluded to the need to frame sustainability issues such as a water risk in financial terms and uncertainties that can be broadly understood and compared across industries. The emerging work on conditional value-at-risk models to water risk and allocations represents a constrained probabilistic approach to quantify and manage unexpected water-risk losses, characterised by low frequency, high severity, and uncertain duration. Lastly, the data needed for both financial and physical analyses are spotty, sometimes proprietary, and often based on pilot or region- and company-specific programmes. Hence, more data and tools are needed. Academic research, NGO programmes (e.g. WRI-Aqueduct and WWF-DEG Water Risk Filter), and new commercial analytics (e.g. Bloomberg NEF, MSCI Risk Metrics) are starting to integrate the physical, reputational, and regulatory risk category data with financial metrics and investment information. A more detailed understanding of the probabilistic business impacts from managing this unpredictable, variable, renewable natural resource within a wide spectrum of users will be necessary to inform more sustainable business water-risk strategies. The motivation and framework provided herein is intended as an organising tool to help guide corporate strategy development, and to build cases that demonstrate the relationship between water-risk mitigation and opportunity-cost metrics.

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