

Analyzing and valuing water risk

Concept note - December 2014

Key points :

- This paper describes an approach to assessing and quantifying the financial magnitude of corporate exposure to water scarcity risk.
- The approach acknowledges a broad consensus that one underlying driver of water scarcity is the discrepancy between the *cost* of water and the *value* of water.
- The approach uses this discrepancy between cost and value of water as an indicator of risk exposure, on the basis that water costs will increase over time.
- A 'shadow price' that reflects the total economic value of water in different locations can be calculated as a function of local water scarcity and other socio-economic parameters.
- The discrepancy between shadow price and current cost of water is used to quantify a level of potential financial exposure.
- Although the precision of this approach will reflect available data, it provides a tangible, quantifiable estimate of financial impact that can provide context to corporate risk mitigation and a focus for further analysis.

NB: This concept note represents a draft paper on work in progress, prepared for discussion with project partners and Expert Council members in December 2014, and may not be cited, quoted or distributed without prior permission from Anders Nordheim at UNEP FI or Liesel van Ast at GCP.

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Introduction

Context

This working paper is prepared as part of a pilot project overseen by UNEP and GCP as leaders of the Natural Capital Declaration (NCD), the German Association for Environmental Management and Sustainability in Financial Institutions (VfU) and the German International Cooperation (GIZ), commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ).

The project aims to develop methodologies to quantify water risks in fixed-income investments and incorporate them into the credit risk analysis for corporate bond valuations. It will produce a first-cut framework and demonstration tool to apply this framework to assess water risks in corporate bond portfolios and integrate water scarcity indicators into credit risk assessments. The framework and “Corporate Bond Water Risk Tool“ aim to build the capacity of finance professionals.¹

The broader aim of this project is to build a lever through which material environmental externalities can be incorporated in global capital markets. The initial focus of this work is water scarcity relating to availability or quantity, rather than quality, although the two issues are linked.

Background

Global institutions including the United Nations, the Organisation for Economic Cooperation and Development (OECD), and the World Economic Forum have highlighted the growing importance of water scarcity.

“Unsustainable economic practices are affecting the quantity and quality of the water at our disposal in the years to come. Rapid urbanization is creating huge pressure on water use and infrastructure, with lasting consequences on human health and urban environments. These changes make water an increasingly scarce and expensive resource. [...] (United Nations)

“The global economy is not running out of resources any time soon. But bottlenecks resulting from the relative scarcity of land, water and energy are time and place specific. For instance, water [...] is not always available for human use in the quantities or at the quality, time and place required.” (OECD)

Businesses are increasingly aware of water-related risks and are active in understanding and mitigating these.

¹ Methodologies developed under the project will be open source. However, some of the underlying data required for the analysis may be proprietary.

“Water security [...] is one of the most tangible and fastest-growing social, political and economic challenges faced today.” ([World Economic Forum](#))

“We aspire to achieve responsible water management throughout our value chains and operate in an environment where all people and businesses have access to safe and reliable water supply and adequate sanitation. Collaboration is key to develop scalable and impactful solutions.”

(WBCSD Water Leadership Group)

“Although companies could consider strict regulations that limit their activities a business risk, in reality, water-intensive companies are also negatively affected by a lack of regulation on other actors in their watershed – a lack that eventually leads to the depletion or degradation of a shared resource.”

(CEO Water Mandate and WWF)

Partnerships between governments, private sector and civil society organisations have been formed to provide joint leadership and understanding.

“World trade in food and energy resources means our interconnected water security problem is global. Water resource management transcends the needs of any single people, place or sector and instead has an impact on global [...] economic activity.”

(2030 Water Resources Group)

Water issues are becoming a significant factor affecting growth and profitability of companies in many regions of the world. Financial institutions that provide credit to affected companies are therefore increasingly exposed to these risks.

Terminology

When discussing issues relating to water risks, there can be confusion over terms that are related and that may have been used differently in other reports or sources. For example ‘water scarcity’ and ‘water stress’ are often used interchangeably, and there is often misunderstanding of what we mean by ‘value’, ‘price’, ‘cost’, and ‘benefits’.

As much as possible, for the purpose of this paper, we will follow the definitions as discussed in existing guidance materials that have been prepared by the [World Business Council for Sustainable Development](#) and the [CEO Water Mandate](#), as listed in [Appendix 1](#).

Our approach

Overview

We aim to use the concept of “Total Economic Value” (TEV) – the economic value of water to society – as a basis for analyzing company financials in corporate bond credit assessment. The TEV concept is an aggregation of the values to society, whether direct or indirect, via the market or non-market mechanisms, as a result of the water’s use or existence.

For the purpose of this paper, we will use the term ‘*shadow price*’ as equivalent to, and representing, the total economic value of water. We identify the difference between shadow price and market price of water as an indicator of potential financial exposure, and we will use this to test the sensitivity of corporate credit assessment to water risk.

This approach is consistent with the [Integrated Water Resource Management principles](#) that water has an economic value in all its competing uses and should be recognized as an economic good.

The basic steps of our approach to quantifying financial risk for a company are as follows:

Step 1: Identify water usage by company X at location of interest ($m^3/year$).

Step 2: Identify the current cost to the company for the water used ($\$/m^3$).

Step 3: Determine a shadow price of water at the location of interest ($\$/m^3$).

Step 4: Calculate the *potential financial impact* on company X (in $\$/year$) by multiplying water usage by *potential* changes to water costs, based on either:

- a proportion of the shadow price such as 25%, 50%, 75%, 100%; or
- the *magnitude of price exposure*, ie the gap between shadow price and current water cost for company X.

This potential financial impact can then be incorporated into the debt-leverage ratios and related analyses that form the basis of corporate credit risk assessment and ratings.

Data, tools and resources

Alongside growing recognition of water risks as a significant and growing concern for business, several tools and resources have been developed to help companies understand these risks. The approach outlined here is intended to be consistent with, and to build on, these existing tools and recognized methodologies where possible. While this project will develop a new tool or methodology for incorporating water risk in credit assessment, as much as possible it will use existing sources of data. These sources may vary depending on the particular company assessed, the sectoral focus, or the availability of corporate information.

Appendix 2 provides an overview of existing sources of raw data, modelled data, projections and tools relating to water scarcity and risk. Briefly, the data required for the steps of our approach are as follows.

To achieve step 1 (water usage), we need to retrieve data on water use, specific to the company and location of interest. Ideally, this would be identified through corporate disclosures, such as through annual reports or to CDP. For companies that disclose global water usage, but not explicit locational data, we can derive an estimate of locational water usage by using a hierarchy of other location-specific proxies such as:

- Level of production.
- Level of operating expenditure
- Greenhouse gas emissions and/or energy consumption data
- Number of employees.
- Revenues by location

In the absence of any corporate disclosure on water use, there may still be the ability to estimate locational water usage by using average water intensity estimates that have been developed by the [Water Footprint Network](#) and others, alongside the location proxies above. To achieve step 2 (water cost), we need to identify whether the company purchases water from a supplier (such as municipal supplies), or whether the company has developed its own water abstraction and/or treatment infrastructure, such as desalination, surface or groundwater abstraction. The sources of information on market prices for water, and potential proxies, are outlined in Appendix 2.

To achieve step 3 (shadow price), we need to retrieve data on water availability and use (water scarcity), as well as additional socio-economic factors that would influence the total economic value for water at the location of interest. Our approach to using this data to determine a total economic value for water is discussed further below.

For step 4, the *potential financial impact* on a company, for a given location or facility, will be calculated as:

$$PFI = U_w \times E_w$$

where:

- PFI = potential financial impact
- U_w = water use (by the company of interest at the location)
- E_w = magnitude of price exposure (gap between current cost and shadow price)

Note that this model does not yet consider any potential responses by companies to rising prices, such as altering production volume or implementing cost mitigation actions.

If we have information on the *probability* of risks materializing over time (such as price rises, regulatory change, or reputational impacts) we could calculate the *expected financial impact* as:

$$EFI_t = \sum_0^n \{U_w \times P_n(E_{wn})\}$$

where:

- EFI_t = expected financial impact at time t .
- P_n = the probability of risk materializing to an exposure magnitude of n .
- (E_{wn}) = the magnitude of exposure at level n .

Note that we distinguish between the probability of risk materializing and the probability of future changes in local water stress, due to climate change or other factors. Future changes in water stress would be reflected in the magnitude of exposure, as based on the difference between cost and shadow price. However information on the expected changes in water stress (such as through IPCC projections and/or Aqueduct projections) would also change the likelihood of risks materializing.

Rationale for our approach

The discrepancy between water value and price are considered by many to be an underlying driver of global water problems (eg [European Energy Agency](#), United Nations, [OECD](#), WEF). In water-scarce areas where prices continue to undervalue water, over-exploitation may lead to resource depletion and limited access to available supplies. The demand for water, and rates of extraction, will continue to increase unless private costs more closely reflect true costs to society. The 2030 Water Resources Group has calculated that global water demand may be 40% greater than the currently available water supplies by 2030.

Consequently, considerable efforts are being made by organizations such as the OECD and EU to encourage government authorities and water companies to improve water-pricing policies to move towards full cost pricing or sustainable cost recovery.

Full cost pricing:

In relation to charging for water usage (and recovering costs for water services), this means setting a price that reflects both the financial costs and societal costs of obtaining water, including resource and environmental costs (based on the European Union Water Framework Directive).

Sustainable cost-recovery:

The setting of a mix of tariffs, taxes and transfers to facilitate long-term investment planning that ensures affordability to all categories of users and financial sustainability to service providers (based on OECD 2009).

(text from WBCSD)

In the event of continued pricing that does not reflect economic value, pressure on supplies is likely to grow. This can result in restrictions on access to supplies for competing water users, including business and industry. The *effective price* of water will continue to rise as increased capital and operating expenditure is required to source, treat and transport water resources to users. For example, companies in sectors such as mining, utilities and food & beverage are increasingly incurring direct costs for infrastructure to source and manage water used in production, processing and cooling. The Financial Times recently reported that, according to Global Water Intelligence, companies globally have spent US\$84 billion to conserve, manage or source water since 2011 (*A World Without Water*, 14 July 2014).

Understanding and quantifying the magnitude of exposure

On the basis of the consensus described above, namely:

- that water prices do not reflect full economic value;
- that pressure on supplies will continue to grow, as will costs to companies; and
- policy recommendations for movement towards full cost pricing,

we can predict that the cost of water will move over time in the direction of a closer alignment with the shadow price.

Proposition 1:

Water costs, including actual and effective market prices will increase over time towards shadow price.

Figure 1 illustrates this proposition – that the cost of water (or effective market price) will increase over time towards the total economic value (or shadow price) for water.

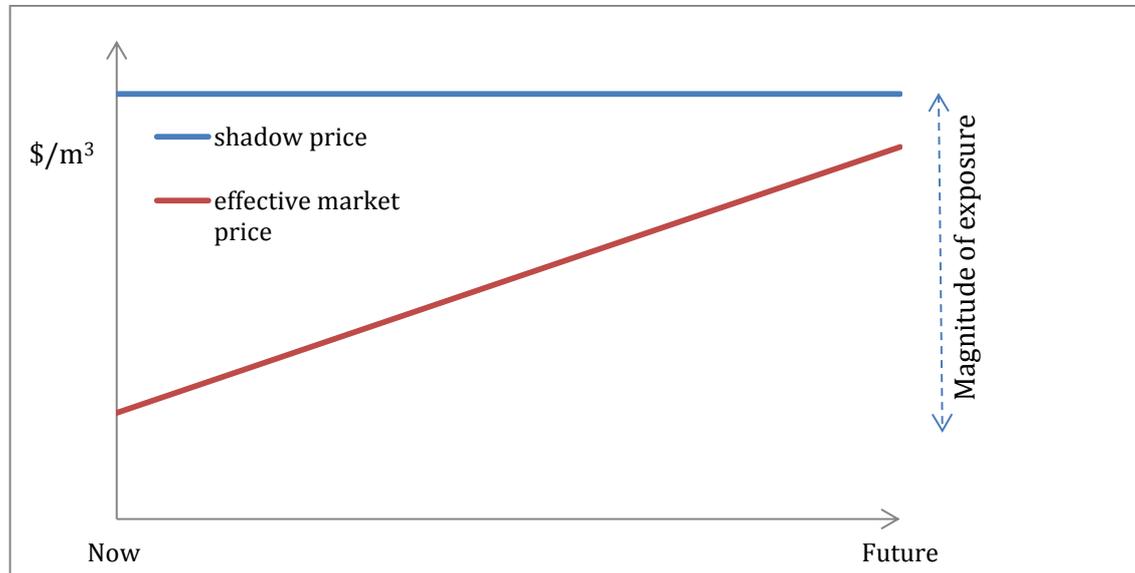


Figure 1: Trajectory of price over time

Note that for simplicity, this illustration does not assume any change in future water demand or availability, ie no change in the water scarcity status or shadow price over time. In a scenario of increasing scarcity, we would expect the shadow price to also increase, and therefore even greater upward pressure on costs due to rising reputational impacts, and increasing technology and infrastructure costs to secure adequate supplies.

We can not predict how fast or how much prices or effective costs might rise, but we can quantify the potential rise – the *magnitude of exposure* – by measuring the gap between current cost and shadow price.

Note that we do not assume that the gap between price and value will be closed within a certain timeframe, or that *actual* market prices will necessarily reach the total economic value through ‘full cost pricing’. The more likely scenario is that with increasing scarcity, the cost to companies – the *effective market price* – will increasingly include costs that are associated with:

- regulatory changes, such as increasing tariff or abstraction charges, quantitative restrictions on total abstraction amounts, or new institutional arrangements such as implementing markets for trading water licenses; and
- reputational impacts, where a water-intensive company operating in a water stressed location may suffer reduced demand from consumers, lose its ‘social license to operate’, or simply need to allocate resources to alleviating reputational damage and allow other stakeholders priority access.

It is this *effective market price* that will move towards closer alignment with the shadow price, causing increasing costs to water-exposed companies.

Although not represented in fig. 1, the market price of water varies considerably, depending on a number of factors including the level of treatment that is applied to improve quality, and the quantity that is used or abstracted. For example, the cost of potable water in municipal supply is significantly higher than the cost of water used by irrigated agriculture, as the treatment of the water for potable supply (filtration, chlorination etc) incurs an additional cost. In many countries, the price of water is heavily subsidized by governments as an essential service and basic human health requirement. This is particularly the case for low initial supply quantities, where demand is less elastic, ie less dependent on price. At higher quantities, the level of subsidization is reduced, with block-tariffs or similar pricing structures.

Determining the value of water

To quantify the magnitude of exposure, we need to calculate the value of water at the location of interest. To do this we will use the concept of Total Economic Value (TEV) to identify the benefits of water to society. The TEV framework has evolved to capture the economic values of the environment that had previously been largely ignored by markets or neglected in classical economic analysis.

TEV refers to sum of all of the values that are received, including marketed and non-market values, use values and non-use values. Figure 2 is a simplistic representation to illustrate the different types of uses and values. There are more complicated versions of this diagram including other value components such as option values, and further breakdown of direct use values into consumptive and non-consumptive use.

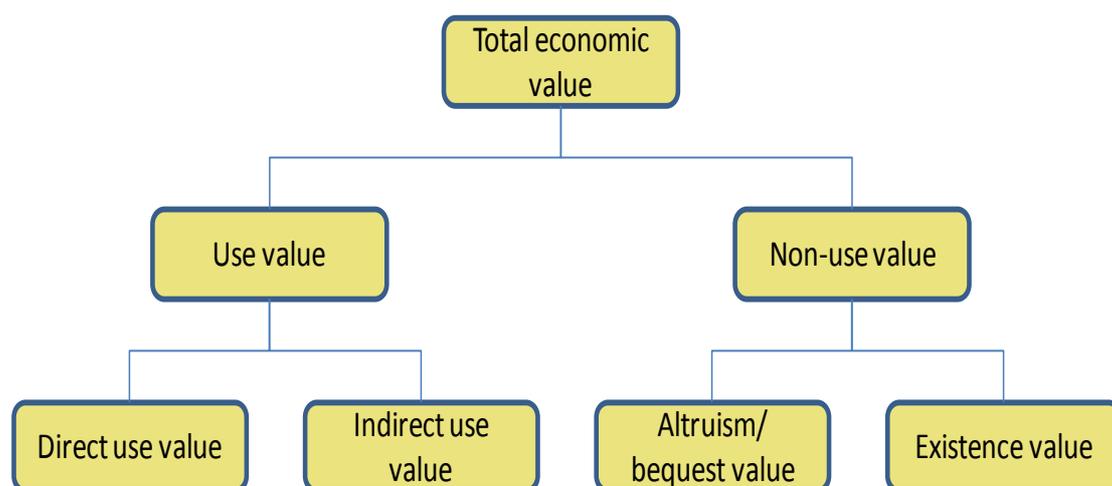


Fig 2. Total Economic Value conceptual framework

In a *Guide to Water Valuation*, the WBCSD describe a related concept of Full Economic Cost:

| | | | |
|---------------------|--|-------------------------|--|
| Full economic costs | Societal costs (externalities) | Environmental costs | Non-water-related impacts (e.g., GHGs) |
| | | Resource costs | Water-related impacts (e.g., loss of in-stream values) |
| | | | Foregone opportunity costs (e.g., other abstraction values lost) |
| | Financial costs (including any internalized environmental or resource costs) | Administration | |
| | | Operation & maintenance | |
| | | Capital | |

There are various valuation techniques that can be used to calculate the value of TEV components, and these are the subject of numerous textbooks and online sources. Recent and comprehensive guidance material is available from, for example the WBCSD, the [Economics of Ecosystems and Biodiversity](#) project (TEEB), and the World Bank's [Wealth Accounting and Valuation of Ecosystem Services](#) (WAVES) project.

It is important to note, however, that many of the materials and inventories of valuation studies are based on a unit of *area* of habitat. In the case of water valuation for this purpose, we are attempting valuation per *volume* of water. We are also seeking to identify average value rather than marginal values.

The values (and prices) for water are very location specific so to accurately quantify risk exposure, we will need location specific data. The most accurate valuation estimate would be obtained by location-specific research using one or more of the valuation methods outlined in the above guidance materials. However, this would be prohibitively time consuming and expensive for the purpose of this project. Therefore we can use a value transfer approach that applies values that have been previously calculated for alternate purposes. We can apply these values in two potential ways:

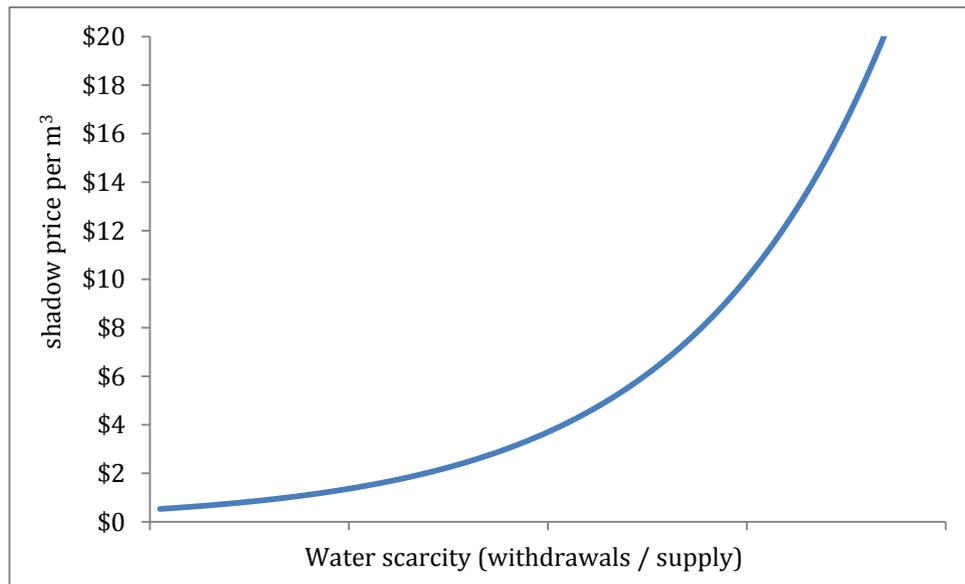
1. A review of existing corporate studies that have identified a shadow price for water (eg Nestlé, Puma and others, including as described by WBCSD) and use these values as reference points or benchmarks for *direct value transfer*.
 - *Advantage*: this would be faster and easy to map against locational data on water scarcity, to provide a global overview.
 - *Disadvantages*: the estimates may be industry / sector specific, and / or location specific. If so, the reference values would need to be retrieved from sites with equivalent biophysical and socioeconomic characteristics, and it may be difficult to determine a precise relationship with water scarcity.
2. A meta-analysis of existing water valuation studies where volumetric estimates have been identified, and use multiple regression analysis to determine a *value transfer function*.

- *Advantages:* more accurate values based on location-specific explanatory variables (scarcity data and other socio-economic parameters)
- *Disadvantages:* more time consuming, and difficult to know how much more precision can be provided by additional variables.

Proposition 2: a ‘shadow price’ can be calculated based on location-specific water scarcity information and a combination of socio-economic variables.

From the information publicly available, it appears that the approach followed by [Trucost](#) (initially for the Puma study, but also in subsequent work and recently the [Water Risk Monetiser](#)) is similar to the second option above. In the Trucost approach, a sample of comparable valuation studies from the USA in the 1990s was used to determine a value transfer function linked to water scarcity, that was used to infer values in other locations. The approximate relationship used by Trucost is illustrated in figure 3.

Figure 3: relationship between scarcity/stress and shadow price (after Trucost)



In this project we will test the feasibility of incorporating additional explanatory variables into our model, such as:

- Total supply (ie not just ratio of withdrawals to supply)
- Proportion of consumptive withdrawals
- Population size and location
- Per capita income
- Health indicators, such as sanitation and improved water sources
- Proportion of urbanised population
- Inter-annual variability

We can identify some *a priori* expectations about the influence of the explanatory variables on the dependent variable (shadow price).

| Variables (X) | Units | Effect of increasing X on value |
|--|--------------------------|---------------------------------|
| Water scarcity | Ratio (0-1) | Increasing (exponentially) |
| Total renewable supply | Volume (m ³) | Decreasing |
| Proportion of consumptive withdrawals (per country) | Ratio (0-1) | Increasing (exponentially?) |
| Population size within 50km radius (or downstream) | Thousands | Increasing (linear) |
| Per capita income | \$ | Increasing (linear) |
| Health indicators (improved water sources, sanitation) | | |
| % urbanised population | | |
| Local environmental values | | |

Expected Outputs

The expected outputs for this component of the project will be:

1. A value-transfer function in the form of

$$WP_{SL} = \alpha + f\{WS_L, TW_L, P_L, I_L, H_L, E_L\} + \mu$$

where:

- WP_{SL} = local 'shadow price' for water
 - WS_L = local water stress ratio
 - TW_L = local total water available
 - P_L = local population (eg within 50km)
 - I_L = local per capita income
 - H_L = local health impacts of reduced water
 - E_L = local environmental values
 - α = intercept (minimum value)
 - μ = residual error term
2. Using this value transfer function we can build a spatially explicit dataset of water values, and a map demonstrating water values, adjusted for parity as necessary.
 3. By calculating the discrepancy between shadow price and effective market price for specific locations and companies, we will be able to quantify the potential financial impacts for exposed companies. These impacts can then be incorporated into the

debt-leverage ratios and related analyses that form the basis of corporate credit risk assessment and ratings.

Discussion

Caveats

There will be an inevitable degree of uncertainty in our calculations. The data we're looking at here is approximate, modeled or average, even with specific sites. If our water stress levels are defined at catchment scale, then our values are also. If scale of water consumption data is country level, then our values are also. If corporate exposure is approximated by proxy data, then our estimates of risk inherit the same degree of uncertainty. Company-specific information on water pricing will be based on publicly-available information. Global data on water pricing is incomplete and not available at a water basin level, so the analysis will be based on estimated water costs for each company, rather than actual costs, except where reported by a company in its annual /sustainability report.

However, we will have a scientific basis for setting the boundaries on which to test corporate credit assessment, company revenue projections and EBITDA ratios etc. We can choose to test against, for example, 30%, 60%, 100% of the calculated shadow price, to represent future market price, regulatory impact and reputational impact.

“Measuring and valuing environmental externalities on the scale required is not a precise exercise and requires significant assumptions in a number of areas. However, the key business value lies in understanding the scale, scope and trajectory of PUMA’s impacts on the environment”

[\(Puma\)](#)

Feedback

At the first project workshop and webinar on 8/9 December, representatives of financial institutions and members of the expert advisory council provided valuable feedback and suggestions on the proposed approach. These included:

- Clarifying that the shadow price (and potential financial impact to companies) represents a compilation of effective costs technology costs, regulatory changes and reputational impacts, in addition to market prices.
- Focusing on the concept of Total Economic Value rather than social value for consistency and impact.
- Exploring the issue of non-linear change, such as stepwise change and threshold changes, and how this could be incorporated in the model.

- Modifying our approach where necessary to account for potential differences in impacts for non-consumptive water users, particularly highly exposed sectors such as power generators.
- Exploring whether historical trends in water pricing in areas of scarcity can be used to extrapolate and forecast potential price rises in other water-stressed areas.
- incorporating into the valuation work where feasible:
 - option values,
 - probabilities of forecast changes in water stress,
 - country-level institutional risk indicators,
 - Additional data on near-term event risk (e.g. drought forecasts and low flow indicators where available),
 - Downstream environmental values.

These suggestions have been taken on board, and incorporated into this revised concept note where feasible, particularly improving consistency of terminology and articulating potential impacts as clearly as possible. We also note that the TEV and shadow price calculations should be interpreted as a boundary reference or benchmark against which companies *may* be tested, and that a comprehensive analysis of credit risk would likely include several layers of stress testing.

The complexity of the value-transfer function and explanatory variables to include was the topic of substantial discussion during the workshop and webinar, and a range of additional data was identified for potential inclusion. It is difficult to predict at this stage how many of these options can be included in the final model, ahead of the actual meta-analysis which is yet to be undertaken. However, where we can access consistent, accurate and spatially explicit data available, we will attempt to include as much of these suggestions as possible, where it provides greater precision to the valuation estimates.

Appendix 1: Terminology

(as per [World Business Council for Sustainable Development](#) and the [CEO Water Mandate](#))

Water scarcity - refers to the volumetric abundance, or lack thereof, of freshwater resources. Scarcity is human driven; it is a function of the volume of human water consumption relative to the volume of water resources in a given area. As such, an arid region with very little water, but no human water consumption would not be considered scarce, but rather “arid.” Water scarcity reflects the physical abundance of freshwater rather than whether that water is suitable for use. For instance, a region may have abundant water resources (and thus not be considered water scarce), but have such severe pollution that those supplies are unfit for human or ecological uses.

Water stress - The ability, or lack thereof, to meet human and ecological demand for freshwater. Compared to scarcity, water stress is a more inclusive and broader concept. It considers several physical aspects related to water resources, including water availability, water quality, and the accessibility of water (i.e., whether people are able to make use of physically available water supplies), which is often a function of the sufficiency of infrastructure and the affordability of water, among other things.

Water risk - The possibility of an entity experiencing a water-related challenge (eg. water scarcity, water stress, flooding, infrastructure decay, drought). The extent of risk is a function of the likelihood of a specific challenge occurring and the severity of the challenge’s impact. The severity of impact itself depends on the intensity of the challenge, as well as the vulnerability of the actor.

The CEO Water Mandate’s guidelines describe water risk in two ways:

1. Type of risk:

Physical – Having too little water, too much water, water that is unfit for use, or inaccessible water

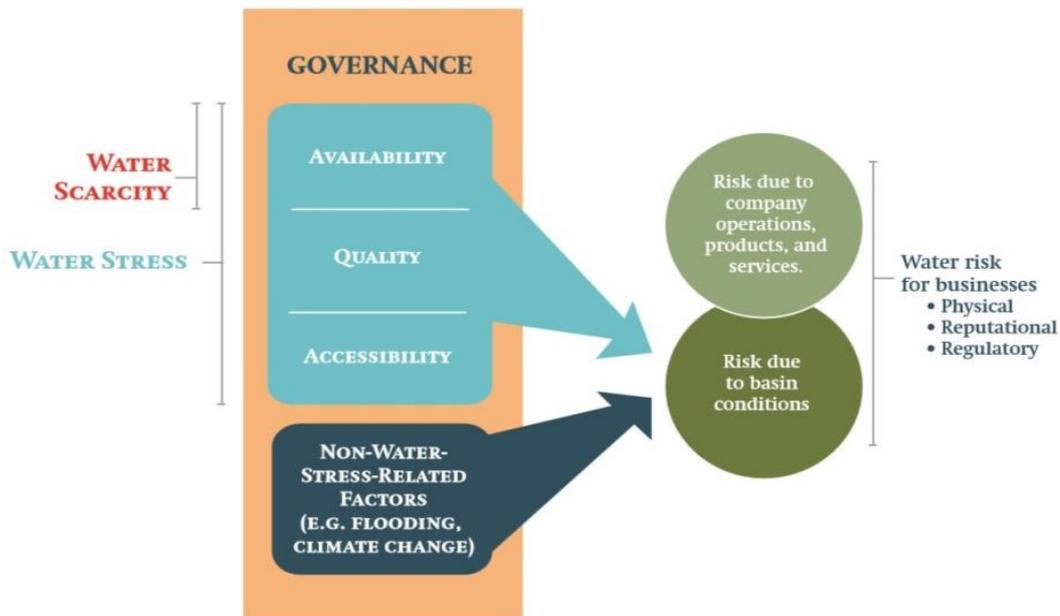
Regulatory – Changing, ineffective, or poorly implemented public water policy and/or regulations

Reputational – Stakeholder perceptions that a company does not conduct business in a sustainable or responsible fashion with respect to water

2. Source of risk:

Risk due to company operations, products, and services – A measure of the severity and likelihood of water challenges derived from the way in which a company or organization, and the suppliers from which it sources goods, operate and how its products and services affect communities and ecosystems.

Risk due to basin conditions – A measure of the severity and likelihood of water challenges derived from the watershed/basin context in which a company or organization operates, which cannot be addressed through changes in its operations and requires engagement outside the fence.



In this paper we focus on physical risks (acknowledging that regulatory and reputational risk contribute to real and effective costs), and analyze the combined effect of company-specific risk and basin-related risks.

Cost - The value that must be given up to acquire, obtain or achieve something. A loss of value is considered to be a cost. In relation to water, costs may include market tariff, or things like abstraction, transport, treatment and disposal. These costs are quite different for different users (municipal vs agricultural / industrial users)

Price - The amount of money that is expected, required or given in payment for something. In a single market transaction, the price is equivalent to the cost. In relation to water, the price depends largely on whether it is purchased from a supplier or obtaining through private means. If from a supplier, then the price will depend on the tariff set, which can be linear or block pricing or a combination of the two. If obtaining through private means, then the *effective price* will be the sum of the costs involved, such as abstraction licenses, infrastructure and technology costs.

Benefit - Something that promotes or enhances human well-being. A gain in value is considered to be a benefit, as is a reduction in cost. The benefits received from water can be described under the Ecosystem Services framework.

Value - The importance, worth or usefulness of something. The value of benefits received by water can be described in several ways, including:

- stock value that is measured at one specific time, and represents a quantity existing at that point in time (eg value of a lake)
- flow value that is measured over an interval of time, analogous to the rate of use or consumption (eg m³ / day)
- average value (the total value of a stock divided by the size/quantity of stock) and
- marginal value (the value of one additional unit of stock).

Importantly we need to distinguish between the value to an individual and the value to society more broadly. In this paper we use the concept of total economic value to determine a social value, or shadow price.

Appendix 2: Overview of existing data and tools.

Data

For the purpose of this project we are looking at two main types of data:

- Bio-physical data that describes water supply, withdrawals and availability;
- Bio-economic data that describes water consumption, intensity of production, and market costs.

Note that biophysical data provides information relating to overall supply and demand, while the bio-economic data provides information relating to an individual company's level of exposure.

Global datasets of bio-physical information are inherently complex, expensive to maintain and often difficult to compare across spatial scales or timeframes. As water issues are inherently catchment-specific, we need datasets that are spatially disaggregated to catchment level or better. We also need to align historical data with current timeframes and future projections, where necessary.

Sources of biophysical data

The [FAO AQUASTAT](#) database is probably the most comprehensive global database of water availability and withdrawal at country-level, with substantial historical data available. It includes data collated or aggregated from external sources, internal estimates, and modelled data.

The Pacific Institute's [Worldwater.org](#) provides water data from a wide variety of sources, including water supply and use by country and by urban-rural split. It also provides data on access to improved water and sanitation by country, renewable freshwater supply, and assessment of water quality satisfaction, among others.

NASA's [Global Land Data Assimilation System](#) Version 2 (GLDAS-2) provides a variety of satellite and ground-based observational data, including surface runoff, soil moisture, snow water equivalent, canopy water storage, subsurface runoff and evapotranspiration.

The [Global Water Scarcity Information Service](#) (GLOWASIS) project is a collaborative European project that uses Copernicus satellite data. The project appears to be concluded and website functionality is limited, but the data remains available for download.

Sources of bio-economic data:

The most accurate and detailed source of company specific information is likely to come from the companies themselves, either through annual reports or disclosures to third party ESG rating companies such as [CDP Water](#). In the absence of such company-specific information,

several models have been developed that provide generalized information on water use and consumption for different sectors.

The [Water Footprint Network](#) (Hoekstra, Mekonnen et al) provides information on direct and indirect water use of an individual consumer, producer, or country. The water footprint of an individual, community or business is defined as the total volume of freshwater used to produce the goods and services consumed by the individual or community or produced by a business. The database holds detailed water consumption details for different crops and agricultural products, but much information is averaged over the period 1996-2005.

The [Water Global Assessment and Prognosis Model](#) has been developed at the University of Kassel, and comprises two main components: a Global Hydrology Model and a Global Water Use Model which has been used to compute water stress across 10,000 'first-order' river basins around the world.

Market prices

For market prices, there are a number of ways that we can identify a location-specific value. *Municipal water* supply tariff charges are publicly available, and can be identified easily through online information or similar basic research.

[Global Water Intelligence](#) provides information to developers, suppliers, financiers, governments and utilities seeking information and analysis about the global water market. Through a subscription, GWI provide research reports and data relating to market prices of water supply, infrastructure and technology across municipal agricultural and industrial sectors. Their municipal tariff survey provides information about urban water supply costs.

For other forms of abstraction and water use, identifying values is more challenging and can be less precise.

In many countries, abstraction of surface water for irrigated agriculture requires water licenses or permits that allow for a particular quantity of water at a specific cost. Similarly, charges often apply for groundwater abstraction, although the cost of groundwater abstraction is often less.

In a few countries or river basins, there are markets in which water abstraction licenses can be traded. These water entitlements exist as a property right (separate to land property rights), and trading prices in the market can be identified.

Corporate expenditure data

In the absence of accurate or available information, we need to consider indirect data, or proxies, to infer the price or private cost for individual companies. A hierarchy of proxies could include:

- Corporate disclosures on annual expenditure on water supply infrastructure, operating costs or efficiency measures (corporate reports, or to CDP)
- Average expenditures for an industry sector for water

Sources of modelled/mapped data:

The World Resources Institute's [Aqueduct](#) project is an online database of spatially explicit water risk indicators, represented visually by a GIS mapping facility. Aqueduct demonstrates twelve water related risk indicators, which can be analysed separately or aggregated under broader categories of physical quantity, physical quality, regulatory and reputational risks, with different weightings available for different sectors. The entire spatial dataset is available for download, or data for specific locations can be analysed and exported.

The [WWF/DEG Water Risk Filter](#) is an online tool that allows investors and companies to analyse water-related risks across the globe. The risk assessment is based on a company's geographic location (basin-related risks) and impact (company-specific risk). The Water Risk Filter combines the functionality of other existing data (eg Water Footprint Network) into one tool, and provides input for other tools, such as the CDP Water questionnaire. Data input for a particular facility can generate water risk information for that location, which can be exported. However it does not appear possible to download the entire dataset for external use.

Stephan Pfister (2009) has developed a [life-cycle impact assessment model of water use](#), looking at impacts on human health, ecosystem quality and resources. This model uses data from many different sources (WFN, WaterGAP etc) to identify the impacts of freshwater consumption.

Tools for analyzing company exposure

Both WRI Aqueduct and the WWF/DEG Water Risk Filter provide insight into company exposure based on a weighting of the different risks.

The World Business Council for Sustainable Development (WBCSD) has developed a [Global Water Tool](#) that can be used to compare a company's water use, wastewater discharge, and location with information on available water, sanitation and population, on a country and watershed basis. The Global Water Tool can generate metrics that describe water use, production intensity and risk, as well as reporting indicators for corporate reporting purposes.

The Global Environmental Management Initiative has developed the [GEMI Local Water Tool](#) - a free tool for companies and organizations to evaluate the external impacts, business risks, opportunities and management plans related to water use and discharge at a specific site or operation. It was developed in cooperation with the WBCSD and has capacity to transfer results across tools.

The [CERES Aqua Gauge](#) is a tool for companies to analyse and communicate their water risk management approach, and for investors to understand how well companies are managing water-related risks and opportunities. It is an Excel-based tool that produces a graphic output

of a company’s existing water risk management approach, evaluating core aspects of water risk management on a sliding scale from ‘initial steps’ to ‘leading practice’.

Tools for understanding impact

The [Water Risk Monetiser](#) is a new tool developed by Ecolab and Trucost that provides information to help businesses understand the impact of water scarcity and to quantify those risks in financial terms. The premise of the Water Risk Monetizer is that the more scarce water is, the higher the value of the water and the higher the risk for businesses that rely on the water source.