INTEGRATING WATER STRESS INTO CORPORATE BOND CREDIT ANALYSIS

Benchmarking companies in three sectors

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Commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ).

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- Internal and external communication and reporting of sustainable performance and action on climate change.
- Environmental, Social and Governance (ESG) factors in lending and investing processes.

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The project team has developed a methodology and Corporate Bonds Water Credit Risk Tool in partnership with Michael Ridley, a Fixed Income specialist, and David Boland, an Ecological Economist and Founder and Managing Director of DBRM Associates.

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- **Bancolombia**
- **Banorte**
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Usage of the Corporate Bonds Water Credit Risk Tool and methodology

The project development team which includes the NCD, GIZ and VfU would appreciate information on whether and how financial institutions and service providers are using the Corporate Bonds Water Credit Risk Tool, and any outcomes of its application. To share this information, provide feedback or if you have any difficulties in using the tool, please contact secretariat@naturalcapitaldeclaration.org

Comments from "financial institution Project Partners and Expert Council members" include:

"A very credible effort at taking a complex environmental theme and incorporating it into financial analysis through the linkage of available data and a theoretical water valuation framework," Robeco

"Understanding exposure to water stress, during corporate bond credit analysis, offers financial analysts a unique opportunity to identify potential business risks, and drive increased corporate engagement in water stewardship to mitigate risks and ensure long-term water security," Paul Reig, World Resources Institute

"It aids in the first level screening of companies operating in water stress regions and something to consider as part of enhanced due diligence," UBS

""With trillions needed in infrastructure spending to meet rising demand for water supplies between 2015 and 2030, the tool for fixed income investors enables us to systematically benchmark portfolio companies on exposure to water costs, and to inform opportunities to mitigate this risk," Calvert

"Introducing the concept of 'total economic value' shows the ambition for the tool, which is to reflect the full value of water availability and recognise how variation across locations and uses can impact a company's bottom line. This ambition is to be lauded. While data limitations are inevitable at this stage – as acknowledged by the developers - the tool can encourage further analyses to improve the evidence base. This would be a significant gain for corporate bond analysts." Allan Provins, Economics for the Environment Consultancy

CONTENTS

Glossary of terms 6

Foreword from BMZ 7

Financial Institution Project Partners' Foreword 8

Part 1: Executive Summary 9

How is water use relevant to credit risk? 9

What does the GIZ/NCD/VfU Corporate Bonds Water Credit Risk Tool do? 9

Key findings 11

Potential applications of the model 12

Part 2: Integrating Water Stress into Corporate Bond Credit Analysis 13

2.1 Introduction 13

2.2 Drought in California and Brazil 13

2.3 The Rating Agencies are Responding 15

Part 3: Open-source Model – An Introduction 16

3.1 Shadow Water Pricing 16

3.2 Integrating Shadow Water Prices in the Corporate Bonds Water Credit Risk Tool 17

3.3 Country-Level Shadow Prices Estimated in the Beverages Sector 18

Part 4: Results 20

4.1 Scenario Analysis to Model Current and Future Risk 23

4.2 Mining Sector Analysis 25

4.3 Power Sector Analysis 25

4.4 Beverages Sector Analysis 26

4.5 Impact on Bonds 27

Part 5: Methodological Issues 29

Part 6: Extending the Use of the Model 31

6.1 Due Diligence and Responsible Ownership Activities 31

6.2 Next Steps 32

Appendices 34

Appendix A: Geospatial Data and the Total Economic Value (TEV) of water 34

Appendix B: Guidance on Using the Tool 38

Appendix C: Bloomberg Water Risk Valuation Tool (WRVT) 43

Appendix D: Bibliography 45

GLOSSARY OF TERMS

Concept	Explanation
Shadow price of water	In order to include environmental indicators in economic analysis, their costs and benefits need to be expressed in monetary terms. Due to inadequate market pricing or regulation, the price paid for water often does not reflect the actual costs and benefits of water to all potential users at its source. Therefore, it is necessary to adjust the price paid by users to reflect a more accurate valuation of the resource. The resulting adjusted or estimated price is called a "shadow price".[1]
Total economic value (TEV)	The Total Economic Value (TEV) concept is drawn from environmental economics. A TEV framework provides a structured approach to estimating the economic value of the benefits that environmental assets provide to society. In this study we apply the TEV framework to assess the value of water by calculating values for the direct and indirect benefits of water use in U.S. Dollars per cubic metre of water (US$/$m^3$). We sum the estimated economic value of benefits of water use in four categories: Agriculture, domestic supply, human health and environmental services (supporting biodiversity). The function includes two independent variables – water stress and population. Our approach only takes account of the "use values" of water (direct use, indirect use, option) in the TEV framework, and excludes "non-use values" (existence, bequest, intrinsic). Our method may therefore underestimate the full value (or TEV) of water, and the result is therefore more accurately referred to as a shadow price. In this paper, the term "TEV" relates to the environmental economics framework used to estimate the value of water, while "shadow price" refers to the result of this estimation using our analysis framework.
Water stress	Water stress measures the ratio of total water withdrawals in a catchment in a given year (the sum of domestic, industrial, and agricultural) to the total available water (the amount available in the same catchment averaged over a long time period). Higher values indicate more competition among users. Water stress is one independent element of the shadow price calculation, alongside population. This paper uses the terms water stress and water scarcity interchangeably. Source: World Resource Institute.

1 UN Department of Economic and Social Affairs, Statistics Division (2012) System of Environmental-Economic Accounting for Water

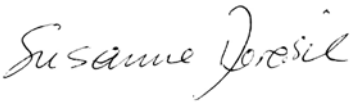
FOREWORD FROM BMZ

Climate change and the degradation of our ecosystems are among the main challenges of the 21st century. Some consequences, such as droughts, increasing water scarcity, rising sea levels and more frequent flooding are already felt across the globe and impact economic activity as well as human lives. The effects of climate change and ecosystem degradation will disproportionately affect the poor and already vulnerable, as their livelihoods depend most directly on natural resources and they are least equipped to absorb economic shocks. Climate change and ecosystem degradation are thus important topics for German development cooperation.

In order to limit climate change to two degrees and to halt the degradation of our ecosystems, we need to develop low-carbon, resource-efficient and environmentally sustainable economies. Achieving this transformation will require substantial investments in green technology, sustainable infrastructure and resource-efficient production methods. It will require a reallocation of our financial capital away from carbon- and resource-intensive economic activities with a high environmental impact and towards sustainable production methods that minimize the impact of human and economic activities on our ecosystems.

Financial institutions, such as banks, asset managers and pension funds play a central role in the green transformation of our economies, as their lending and investment decisions strongly influence the allocation of capital in our economic system. It is thus crucial that we hardwire environmental indicators into their decision-making processes. We need to ensure that their lending and investment decisions reflect not only the return a project or economic activity provides to its shareholders and lenders, but also the costs and benefits it entails for society as a whole.

Consequently, German development cooperation works with the financial sector to integrate environmental indicators into lending and investment decisions and to mobilize private capital for green investments. As part of this effort, the tool that is presented in this report was developed, which enables finance professionals to integrate water stress in their credit risk assessment. It represents one step forward in our endeavor to change decision making in the financial system. I would like to thank the seven financial institutions, the United Nations Environment Programme Finance Initiative, the Natural Capital Declaration, the Global Canopy Programme, GIZ and the German Association for Environmental Management and Sustainability in Financial Institutions (VfU) for the great partnership in developing this tool.



Susanne Dorasil
Head of the Economic Policy, Financial Sector Division,
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FINANCIAL INSTITUTION PROJECT PARTNERS' FOREWORD

Water scarcity can be significant and is affecting companies in several sectors, in various places, right now. Localised water shortages currently span four continents. Parts of Brazil, the United States, South Africa and China that are dependent on water for agriculture, energy and industry are facing severe supply constraints. Companies rarely report on the effects of supply constraints on their financial statements, making it difficult to track the effects of misalignment of water supply and demand on credit risk. Most water-related costs, such as higher water tariffs, water restrictions due to lack of supply or re-allocations, and capital expenditure to mitigate risks or adapt to physical constraints, are embedded in line items in financial statements. This makes it difficult to identify how water scarcity is currently affecting the financials of companies, and how they could be affected in the future. Opaque and anecdotal information on water-related costs and pricing has left water relatively invisible in the data flows and analytics used to inform investment decisions, despite it being a key input in many production processes and costing business billions of US Dollars annually.

The Corporate Bonds Water Credit Risk Tool provides a systematic approach to modelling corporate exposure to water stress so that it can be factored into credit analysis. It incorporates ratios of supply and demand to identify exposure to water stress and the resulting risk faced by companies into traditional financial analysis. The model's approach of combining geospatial information and corporate water data, with an overlay of water shadow pricing, is useful to make company-level exposure to water stress quantifiable in credit analysis. Taking part in the project has been a valuable learning experience, and having the opportunity to provide input at key stages has helped to make sure that the tool can be used in credit assessments, benchmarking, corporate bond valuations, engagement programmes and developing new investment strategies. The tool provides useful insight to evaluate companies on water risk against sector peers. We hope that we have helped to deliver a tool that is credible to the financial market. Its workings are transparent and it has the functionality and flexibility that are useful to integrate water as a factor into products and services offered by financial institutions.

It is a practical step towards developing a more systematic approach to understanding portfolio exposure to water risk. This will become increasingly important as variability in rainfall patterns, ecosystem degradation, population growth and growing demand from agricultural and industry contribute to growing competition for water resources.

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PART1: EXECUTIVE SUMMARY

Companies that depend on water and operate in locations where water withdrawals are high relative to available water supply are exposed to water risk. Their costs for obtaining the amount of water they need to sustain their operations might rise abruptly or gradually, impacting their profitability, competitiveness and finally their ability to repay their debt.

A new financial model to integrate water stress into corporate bond credit analysis has been developed through a partnership between the Natural Capital Declaration (NCD), GIZ, the German Association for Environmental Management and Sustainability in Financial Institutions (VfU) and seven financial institutions from Europe, the U.S. and Latin America. By combining data on the quantity of corporate water use per production location with cost based on site-specific water supply and demand conditions, the GIZ/NCD/VfU tool for integrating water stress into corporate bond credit risk analysis allows financial analysts to quantify corporate water risk and assess the potential impact of water stress on a company's credit ratios. Fixed income analysts and portfolio managers can use the Corporate Bonds Water Credit Risk Tool to benchmark companies and assets in water-intensive industries, such as mining, power and beverages industries on exposure to water stress.

How is water use relevant to credit risk?

For many companies, accessing sufficient quantities of water for operations is becoming increasingly costly, especially in water-stressed regions. On the supply side, continuous overuse of water sources, ecosystem degradation and changing climate patterns with more frequent and severe droughts are rendering water an increasingly scarce resource. On the demand side, population growth is contributing to rising demand from households and agriculture, and competition for water resources is growing within and between water-dependent economic sectors. As a result of these growing supply and demand pressures, we see water-related capital expenditure rising amongst companies that directly withdraw water in catchments with scarce or over-allocated resources. Water tariffs are increasing as utilities attempt to recover higher expenditure to secure supplies. Water shortages have prompted authorities in economies including the U.S. state of California and the Brazilian state of São Paulo to introduce demand management and restrictions, which can limit production. Increasingly uncertain water supply and rising water costs affect the financials of companies, e.g. in the mining, power and beverages sectors. Additional capital expenditures to secure water supply (e.g. through investment in desalination technology), higher operating expenditures due to increasing water prices, production losses resulting from restricted access to water or the loss of a company's social licence to operate as it competes for scarce water resources with the local community, can lead to lower than expected earnings, restrict growth, and affect financial ratios used in credit analysis.

What does the GIZ/NCD/VfU Corporate Bonds Water Credit Risk Tool do?

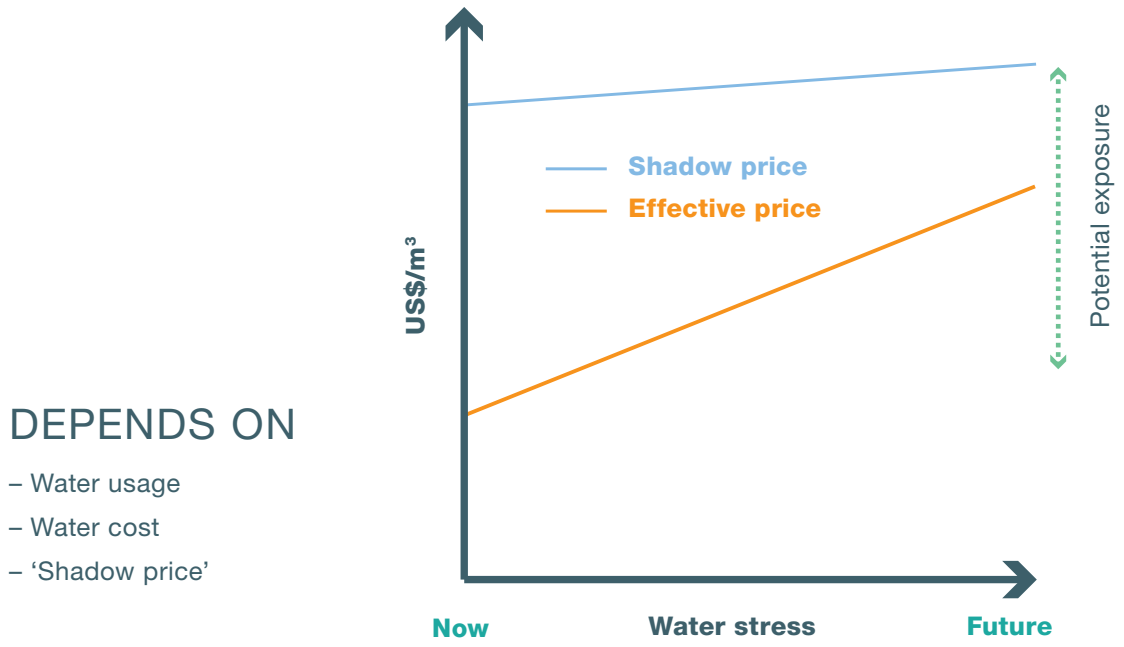
The tool incorporates newly available data from the World Resources Institute on water stress at any location globally into a traditional financial model. Thereby, it enables users to integrate a company's exposure to water stress into credit risk analysis. Users of the tool can benchmark companies on the potential impact of water stress on their credit ratios.

The model uses a shadow price for water as a proxy for exposure to potentially increasing costs for water resulting from water stress. Our analysis found no statistical correlation between urban water tariffs and water scarcity. In the absence of market prices that reflect resource constraints, shadow prices provide a proxy for the magnitude of exposure to water stress. The calculation of these shadow prices is based on a total economic value (TEV) framework – a concept taken from environmental economics. Shadow water

prices are calculated by considering the value of the alternative uses to which this water could be put, if it were not used by the companies analysed (opportunity costs). Where location-specific water use data is unavailable for a company, shadow water prices across a company's assets are weighted by production or assets in each location in order to derive a company-weighted water shadow price to reflect its overall risk profile. A higher company-specific shadow price indicates higher potential exposure to water stress across its operations. By using the shadow price to calculate a company's potential water use costs, water risk is introduced into the company's financial model via operating expenditures. This allows the user to measure the potential impact of increasing water costs on key financial ratios used in credit assessments.

The TEV framework is used to estimate the shadow price of water to provide an 'upper bound' with which the model is able to gauge the magnitude of direct potential exposure for a company, and test the company financials against this exposure. The market price of water might not reach the shadow price, however the costs of water constraints can be internalised through a variety of market and non-market mechanisms, including capital expenditure (capex), physical shortages leading to lower production, and asset stranding caused by loss of water rights.

Figure 1: Shadow price increases with water stress



To illustrate the efficacy of the model, this paper also presents analysis undertaken on 24 companies, eight each from the mining, power and beverages sectors. We apply the new Excel-based model to investigate how these firms' credit ratios could be impacted by water stress, based on the potential costs associated with their water use under current and projected water supply conditions.

The model calculates company credit ratios before and after integrating the shadow price of the water used at their production locations. For some firms, the integration of the full value of water use that takes account of scarcity and population factors has the potential to have a significant impact on their credit ratios, which could lead to a rating downgrade and an adjustment in the value of their bonds.

When the model introduces water as a factor into the credit analysis of companies, the two parameters that determine estimates of how a firm's credit is impacted are the amount of water the firm uses, and the shadow prices that the firm faces for water depending on

the locations in which it produces. These factors, coupled with the financial strength and business risk profile of each company determine the extent to which firms are impacted by water stress in the model.

Shadow prices as a proxy for water risk

The TEV framework attempts to capture the benefits that water provides, in addition to the private benefit enjoyed directly by water consumers. We estimate the use value of four different "services" provided by water, namely water's value for agriculture, domestic supply, human health and environmental services. The model sums these four values to arrive at an overall shadow price. Water stress is one of the two independent variables in our calculation of shadow water prices. The second independent variable is population size within a 50 kilometre (km) radius. Areas that have high levels of water stress and are densely populated will have relatively high shadow water prices, reflecting expectations of increased costs to secure supplies and greater competition for resources. For a full explanation of shadow prices, see Appendix A.

Key findings

- Of the eight mining firms analysed, Barrick Gold and Vedanta are most exposed. Barrick Gold could see its Net Debt/EBITDA ratio rise by 20 per cent to 3.30x in 2017 if it were to fully internalise the costs of its water use. This could cause Barrick Gold's BBB rating to fall to High BB. However, this could be prevented by Barrick Gold's robust EBITDA/ Revenue margins.
- This scenario of full cost internalisation would see Vedanta's Net Debt/EBITDA ratio or leverage rise by 65 per cent to 3.85x in 2017. Although Vedanta's leverage rises quite sharply in our model, Vedanta is already rated Ba3/BB-, so its rating may not change.
- Of the power companies analysed, Eskom (Ba1/BB+Neg), the South African utility, already has extremely high leverage before water costs are added, with Net Debt/ EBITDA of 9.41x in 2017. Once Eskom faces the actual cost of its water use, its financial position deteriorates drastically, with its Net/Debt ratio almost tripling. But Eskom is unusual, being 100 per cent owned by the South African government (though its debts are not fully guaranteed by the government). Being financially stretched, Eskom is likely to be most exposed to water costs through physical constraints on its availability, which can challenge the reliability of existing operations and the viability of proposed projects, imposing additional costs for adaptive measures.
- Sempra, RWE and The Southern Company see their leverage rise quite sharply, when they internalise the full cost of their water use. Sempra Energy could see its High BBB rating fall to a non-investment grade rating: perhaps to High BB, because its leverage

Credit ratings explained

Ratings provide a simple way to communicate views on creditworthiness. Ratings used in this report are from the two largest rating agencies — Moody's Investors Service and Standard & Poor's (S&P). S&P uses 'AAA', 'BB', or 'CC' to communicate relative credit risk, with 'AAA' denoting the strongest creditworthiness and 'C' or 'D' denoting the weakest, or that a default has occurred. BBB- and above are considered "investment grade" – categories of issuers and issues with relatively higher levels of creditworthiness and credit quality. Similarly, Moody's ratings range from Aaa to C. Ratings of Baa3 and above are considered prime.

http://www.standardandpoors.com/aboutcreditratings/RatingsManual_PrintGuide.html
https://www.moodys.com/sites/products/AboutMoodysRatingsAttachments/MoodysRatingsSymbolsand%20Definitions.pdf

rises 97 per cent to 6.74x in 2017 when we estimate current shadow water costs. Power plants may face shut downs or operate at lower capacity in water-stressed areas.

- Our approach may underestimate the risk posed by water scarcity to utilities such as EDF, GdF and RWE, which use a great deal of water for cooling purposes. Our model only analyses the consumptive use of water, and does not apply the shadow price to water used for cooling that is reverted to its source. However, where available, quantities of cooling water are included in the model so that users could adapt it to estimate exposure to this "non-consumptive" reliance on water. In addition, users can assume that utilities with assets identified as exposed to water stress under the model's assumptions will be exposed to additional risk through the dependence on cooling water.
- Introducing shadow water prices does not have a significant impact on the financials of most of the beverage firms analysed. The exception is Femsa (NR/A-), the Mexican bottling company. Femsa's Net Debt/EBITDA ratio more than triples from 0.61x to 2.27x at the end of 2017 when we include water costs. Femsa's relative EBITDA/Revenue margin is small compared to peers like Diageo and A-Busch. Adding water costs could see Femsa's rating fall one notch to High BBB. The concentration of its operations in Mexico increases its exposure to water stress, relative to other beverages firms with more geographically diversified operations.
- The model's approach to the beverages sector is likely to underestimate the risk that water scarcity poses to these companies as it does not consider water risk embedded upstream in value chains. Our analysis only accounts for direct water use in the operations of beverage companies and does not include indirect water consumption through their supply chains.

Potential applications of the model

The Corporate Bonds Water Credit Risk Tool presented in this report is of most immediate interest to credit analysts and portfolio managers working in the bond markets, both on the sell side for banks or on the buy side for asset managers or hedge funds.

Credit analysts can extend the use of the tool to cover other companies in the mining, power and beverages sectors, or to additional sectors that depend heavily on water resources and have bonds outstanding. Analysts can source corporate location-specific water data and conduct research by applying the tool to analyse specific companies, with the potential to extend or adjust the quantitative analysis.

Other bond professionals working in origination and syndication could use the tool to analyse the potential impact of water scarcity on their issuer, before they bring bonds to the market or even before they talk to companies about their issuance needs. Alternatively, rating agencies or companies themselves might use the tool to consider the potential impact of water stress on credit ratings. The model could also be useful for credit risk managers looking to analyse whole portfolios of bonds, rather than individual bonds.

Finally, Environmental, Social and Governance (ESG) analysts and service providers can use the tool to identify firms "at risk" from water stress, firms with whom they could engage, by encouraging stronger disclosure and management practices around water. Follow up activities could include further research into regulatory frameworks, water policies and infrastructure relevant to preparedness for water scarcity.

The shadow prices underlying the tool can be applied to similar models for different asset classes. For example, Bloomberg has included the shadow prices developed under this project in a tool to analyse water risk in mining equities. In addition to the Corporate Bonds Water Credit Risk Tool, a tool that provides only the shadow water price at each location and country is available for download. This tool may be used for a great number of applications where shadow water pricing is needed.

PART 2: INTEGRATING WATER STRESS INTO CORPORATE BOND CREDIT ANALYSIS

2.1 INTRODUCTION

The cost of water is rising around the world, with a 4.3 per cent average rise in domestic water and wastewater bills between 2013 and 2014,[2] according to data from Global Water Intelligence. The average masks the upper end of year-on-year price hikes, with tariffs jumping by one-third in at least 10 cities. It is difficult to find comparable data for industrial water charges, but there is evidence that companies spent US$84 billion worldwide to secure and manage water supplies between 2011 and 2014.[3] Investment drivers include physical water shortages, new industrial processes requiring more or higher-quality water corporate responsibility and new environmental regulations requiring better wastewater treatment.

Firms may face higher water costs through regulatory constraints on access to water, higher water tariffs, physical shortages, higher capital expenditure costs or loss of social licence to operate. The cost of securing water may rise due to changes in precipitation, urbanisation, competition for water from other firms, from other sectors and civil society. Companies are realising that water can no longer be treated as a free raw material, and that it can damage their credit rating, insurance costs and brand value.

The Corporate Bonds Water Credit Risk Tool developed through the partnership between GIZ, the NCD, VfU and seven financial institutions aims to help financial analysts and portfolio managers assess how corporate bonds could be exposed to risks from water stress. The model developed to benchmark companies on water risk exposure currently focuses on three sectors that use a significant amount of water and have a large number of bonds outstanding – mining, power utilities and beverages. For eight companies in each of these sectors the report analyses how their credit ratios would be impacted if they had to internalise the full cost of their water use. By applying a location-specific shadow price for water to estimate the company's potential operational expenditure (opex), the tool calculates the potential impact of water risk on a company's financial ratios.

2.2 DROUGHT IN CALIFORNIA AND BRAZIL

Evidence of the potential impact of water stress on business can be found in regions such as California and Brazil, which have been gripped by severe droughts. California's current drought is in its fourth year in 2015 and in April, the Governor of the State of California directed that the State Water Resources Control Board impose restrictions to achieve a state-wide 25 per cent reduction in potable urban water usage, until 28 February 2016, versus water usage levels in 2013.[4] Farmers in California's Central Valley, the agricultural region that supplies half of the fruit, vegetables and nuts consumed in the United States, are paying 10 times more for water than they did before the drought.[5] Farmers are being forced to leave land unused, businesses and residents face mandatory cutbacks and policymakers are considering desalinating sea water from the Pacific Ocean. Water bottlers are under

2. Clark, P. A World Without Water. UK: Financial Times. 24 July 2014
3. Clark, P. A World Without Water. UK: Financial Times. 24 July 2014
4. State of California Executive Department, Executive Order B-29-15, 1 April 2015
5. Bloomberg, California Water Prices Soar for Farmers as Drought Grows. 24 July 2014

pressure for selling spring water. The drought has spurred Starbucks Corp to announce plans to move its Ethos Water production from California to Pennsylvania.[6] Protestors called for Nestlé, the largest water bottler in the U.S., to stop bottling operations in Los Angeles and Sacramento during the drought.[7]

Hydropower production in California has dropped 60 per cent since the drought started, causing a shift to natural gas.[8] Even at the onset of drought in 2012, several nuclear and thermal power plants in the U.S. were forced to run at lower capacity due to lack of cooling water.[9] A ban on once-through cooling water technologies will come into force in California by 2020 – too late to reduce dependence on water in the current crisis.[10]

Drought caused by deforestation?

The drought in California has been linked to the depletion of the Amazon rainforest.[11] Deforestation is changing the dynamics of clouds, and could be contributing to lack of snowpack and rain in the western United States. Many academic studies also link deforestation of the Amazon Basin to the current drought in southern Brazil. Transpiration from the forests causes the flow of "flying rivers" – winds carry vapour from the rain forest to transport more than two-thirds of the rain that falls in southeastern Brazil. The "sky rivers" move 20 billion metric tons of water – six times more moisture than the Amazon river.[12] Evidence shows that deforestation is causing regional climate change.[13]

Water reservoirs are also critically low in Brazil, where two-thirds of the electricity comes from hydropower. Drought in Brazil is causing a shift to high-cost thermoelectric power, which may contribute to a 70 per cent rise in electricity prices and an increase in greenhouse gas emissions that contribute to climate change.[14] Industry and agriculture in the country's three most populous states – São Paulo, Rio de Janeiro and Minas Gerais – are exposed to the worst drought in over 80 years. In the landlocked state of Minas Gerais, one of three reservoirs serving the state capital of Belo Horizonte, Serra Azul, is down to 5.7 per cent of its volume.[15] Water rationing has been imposed on the largest firms in the country's industrial heartland of São Paulo.[16] The effects of water and electric rationing may cut GDP growth by 1 per cent to 2 per cent in 2015, with economists forecasting a contributing to an expected contraction of more than 2 per cent in 2015.[17] Average urban water tariffs rose by 22 per cent in Brazil and 19 per cent in the United States between 2013 and 2014.

In the short term, responses to physical water shortages include changes in allocations and difficult-to-predict rationing. There is a disconnect between water prices and shortages: as water tariff structures are included in long-term policies for water governance, water prices fail to adapt quickly to situations of water scarcity and instead access to water can become restricted. In contrast to greenhouse gas emissions, inadequate water governance and regulation can increase the risk of constraints.

According to the non-profit organisation CERES, price changes can happen abruptly and lag behind other changes that can be financially material, depending on the sector and volume of water used. Rising costs of securing and managing water supplies are most visible in

6. Bloomberg
7. Clark, P. A World Without Water. UK: Financial Times. 24 July 2014
8. Frankel, T. Western drought steals clean energy along with fresh water at power plants, Washington Post. 26 April 2015
9. National Geographic, Record Heat, Drought Pose Problems for U.S. Electric Power. 17 August 2012.
10. World Nuclear News, California moves to ban once-through cooling, 6 May 2010
11. Kelly, M, If a tree falls in Brazil…? Amazon deforestation could mean droughts for western U.S. Princeton university, November 7, 2013
12. Brooks, and Gomez Licon, Amazon Deforestation May Be The Cause Of Brazil Drought, Scientists Say Huffington Post, 20 April 2015
13. http://wwf.panda.org/what_we_do/where_we_work/amazon/problems/climate_change_amazon/ access 10 August 2015
14. Rio Times, Electricity Bills to Increase by 70 Percent in Rio and São Paulo, 23 February 2015
15. Carnival cancelled as Brazil hits the bottom, Global Water Intelligence, Vol 16, Issue 2, February 2015
16. Moneyweek, Brazil's water shortage is a big bad buying signal, 16 February 2015
17. http://www.reuters.com/article/2015/08/19/brazil-economy-activity-idUSL1N10U0JB20150819

the mining industry, where spending on water increased from US$3.4bn in 2009 to nearly US$10bn in 2013 and was expected to exceed US$12bn in 2014, according to Global Water Intelligence.[18] Access to water has become one of the biggest risks facing the mining industry,[19] making it more important for credit analysts to assess companies' dependence on water and future supplies, and plans to cope with increased prices and possible shortages.

2.3 THE RATING AGENCIES ARE RESPONDING

Rating agencies are responding to some companies' increased exposure to drought and water stress. Standard & Poor's Ratings (S&P) has produced two reports that focus on the California crisis, namely "How will California water utilities fare amid the long drought and new conservation mandates?" (2015) and "California's water system illustrates the near-term impacts of long-term climate change" (2014). While neither led to downgrades, S&P seems to be preparing the ground in case drought-related downgrades are necessary.

S&P, Moody's and Fitch all placed the water utility Cia de Saneamento Basico do Estado de Sao Paolo (Sabesp) on Negative Outlook, as a result of the drought. Sabesp is now rated (Baa3 Neg, BB+ Neg, BB). S&P changed its outlook on Sabesp from Positive to Stable on 23 May 2014, and from Stable to Negative on 23 December 2014. Fitch indeed cut its Sabesp rating to BB from BB+ on 20 May 2015.

Drought in Brazil was mentioned as a factor when S&P cut its Brazil long term foreign currency rating to BBB- on 24 March 2014. Low rainfall was noted as a reason for losses in the Brazilian electricity sector, which might contribute to "fiscal slippage" for the Brazilian sovereign: "The implementation of the recently announced measures to manage losses in the electricity sector (given low rainfall and reliance on high cost thermal energy) with a limited increase in electricity tariffs in an election year may be challenging".[20]

Moody's and Fitch both state that drought puts the ratings of Brazilian hydro generators and electricity distribution firms at risk. Moody's said Brazilian hydro generator ratings are at risk because of lower sales and because they may be forced to buy expensive power in the spot market. Moody's cites four Brazilian power firms as susceptible to downgrades: Centrais Electricas Brazileiras (Electrobas) (Ba2Neg/BBB-); AES Tiete SA (Baa3Neg/NR); Light Energia SA (Ba2Neg/NR); and Duke Energy Int'l Geracao Paranapanema (Baa3/BBB-).[21]

Fitch said that if low reservoir levels lead the Brazilian government to impose power rationing, this could negatively hit hydro generator and the electricity distributor ratings.[22]

The rating agencies are not just exercised by the Californian and Brazilian droughts. They are investigating whether long-term water scarcity trends may impact different economic sectors. Moody's mining sector report entitled *Water Scarcity to Raise Capex and Operating Costs; Heighten Operational Risks* (2013) discussed the challenges of mining in areas where rainfall is consistently low and water stress is high. Moody's expressed surprise that the Peruvian government expects US$52 billion of projects to be carried out over the next 10 years in Peru, despite significant water shortages. S&P is in the process of identifying risk factors, including those related to water scarcity, which are already embedded in its corporate ratings methodology and which can be applied to the analysis of environmental and climate risk in its ratings across all sectors. A Standard & Poor's paper (2012) argues that: "power generators and energy-intensive firms could face more immediate financial risk from water use through business disruption and changes in abstraction licencing conditions".[23]

As the rating agencies become increasingly alert to the issue of water shortages, the financial community will need to strengthen approaches to evaluating corporate bond exposure to water stress.

Credit ratings explained

S&P uses symbols from AAA to D to communicate creditworthiness and credit quality. 'AAA' is the top rating, indicating extremely strong capacity to meet financial commitments. BBB- and above are considered "investment grade" - categories of issuers and issues with relatively higher levels of creditworthiness and credit quality. BB+ to D are considered "speculative grade". A positive outlook suggests that the issuer's rating may be raised, while a negative outlook indicates it may be lowered. [24]

18. Clark, P., A World Without Water. UK: Financial Times. 24 July 2014
19. Ernst & Young (2014), Business risks facing mining and metals 2014–2015
20. Standard & Poor's, Brazil LT FC Rating Lowered to BBB-, 2014
21. Moody's, Protracted drought to continue pressure on Brazilian hydro generators' cash flows, 2014
22. https://www.fitchratings.com/gws/en/fitchwire/fitchwirearticle/Increasing-Risk-of?pr_id=979106 accessed 8 August 2015
23. Standard & Poor's, How Water Shortages in Eastern England Could Increase Costs for UK based Utilities, 2012
24. http://www.standardandpoors.com/aboutcreditratings/RatingsManual_PrintGuide.html Moody's ratings range from Aaa to Baa3 for "prime" long-term ratings, and from Ba1-C for "not prime" ratings or speculative grade. https://www.moodys.com/sites/products/AboutMoodysRatingsAttachments/MoodysRatingsSymbolsand%20Definitions.pdf

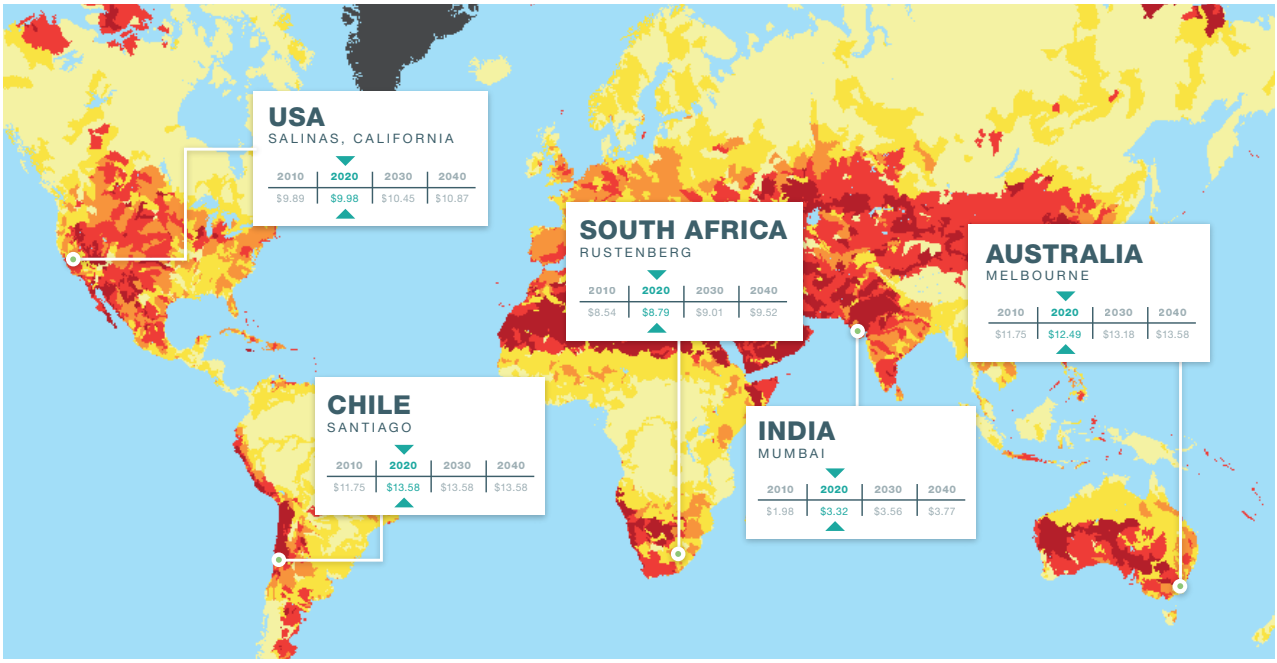
PART 3: OPEN-SOURCE MODEL – AN INTRODUCTION

3.1 SHADOW WATER PRICING

The financial model provided is an open-source Microsoft Excel-based tool. It extends traditional credit analysis, which involves evaluating firms' business and financial risks, to include water stress. Our model calculates five credit ratios for each company. But unlike traditional credit analysis tools, the Corporate Bonds Water Credit Risk Tool can also model firms being charged the total economic value (TEV) of the water that they use which is our 'shadow price'.

Water prices provide a lagging indicator of water risk. Water governance is highly politicised and current water tariffs are not a reliable indicator for local supply-demand dynamics. The price of municipal water for 355 cities around the world ranged from US$0.0/m^3 to US$4.5/m^3 in 2014, according to a Water Tariff Survey published by Global Water Intelligence. Our analysis found no statistical correlation between these urban water tariffs and water scarcity levels at the 355 locations, based on data from the World Resources Institute. Current water costs are inadequate as indicators of exposure to water risk.

Figure 2: Shadow water prices provide a proxy for water stress across geographies and over time



Source of water map: WRI Aqueduct. Shadow water prices from DBRM Associates.

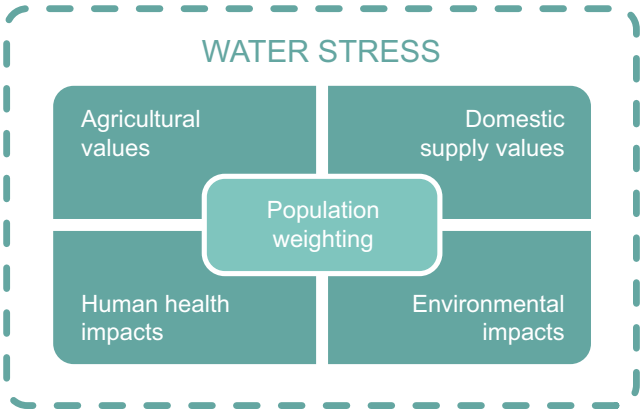
The model aims to overcome this by using the TEV framework to capture the full economic value of water to reflect supply constraints and demand pressures. The evaluation of alternative allocations of water among competing users requires costs and benefits to be expressed in monetary terms, using prices and quantities. The TEV framework covers the external benefits that water provides to society and ecology, in addition to the private benefit enjoyed by water consumers. Since observed prices for water often fail to reflect actual economic values, for example due to government regulation and subsidy, observed market prices need to be adjusted to accommodate distortions.[25] In some cases, there may be no market price, so the value must be estimated.

25. UN Department of Economic and Social Affairs, Statistics Division (2012), System of Environmental-Economic Accounting for Water

Using the TEV framework to calculate the US$/m^3 shadow price of water, indexed to water stress, provides a systematic approach to integrating water risk into financial analysis.[26] The application of the TEV concept was reviewed by the project's Expert Council members in the field of environmental economics (see page 3) to ensure the theoretical underpinnings and methodology used are robust.

In calculating the shadow price of water, we value water used at a specific location, by considering the alternative uses to which this water could be put, if it were not used by the company analysed. The four dependent variables in the equation (the four components of TEV) are agricultural values, domestic supply values, human health impacts and environmental impacts. The two independent variables of the TEV are water stress and population.

Figure 3: Components of the shadow water price



The model includes the shadow price of water to estimate the potential scale of the financial impact of water constraints on companies with operations in water-stressed catchments. See Appendix A to find out more about how the shadow price of water is calculated in the model.

Bloomberg LP has included the shadow water prices that were developed through this project into a Water Risk Valuation Tool (WRVT) that it created in collaboration with the NCD and sponsoring partners Bloomberg Philanthropies. To find out more, see Appendix C.

3.2 INTEGRATING SHADOW WATER PRICES IN THE CORPORATE BONDS WATER CREDIT RISK TOOL

Each of the 24 companies analysed in the model is shown on a separate sheet in the Excel file. The top half of each Excel sheet is a standard credit analyst's company model. The model contains Profit and Loss, Cash Flow and Balance Sheet information for each company, for the years 2013 to 2017. These three statements, which are interlinked, generate five credit ratios used to estimate the credit strength of the company. For a full description see Appendix B.

What is novel about this model is the inclusion of location-specific information about the firms' operations and water use. This is found in the lower part of each company sheet. The model pulls in data on water stress held by the World Resources Institute (WRI) and applies a formula to calculate shadow prices at different locations around the world, in the years 2010, 2020, 2030 and 2040. The tool enables users to calculate the shadow price of water at all land-based locations for these years.

With the mining companies, we ascertain the location of all of their main mines and for the power sector we identify the location of power generation plants. Based on the longitude and latitude of each site the model identifies the level of water stress at that location using WRI data, and then calculates the shadow price of water to identify the value of water indexed to water stress at that specific location.

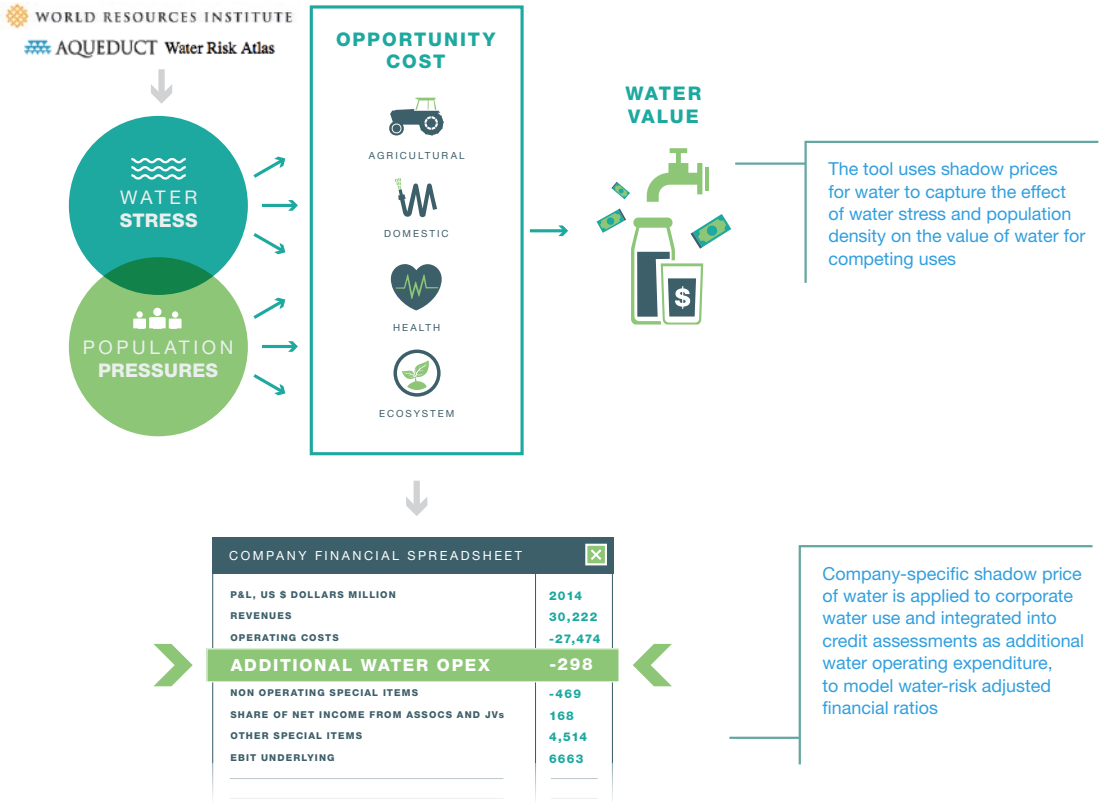
26. http://www.equariusrisk.com/2015/01/24/business-water-risk-can-shadow-risk-pricing-inform-capital-markets/ accessed 23 June 2015

The shadow price of water at all of a firm's main locations is then weighted by the amount of water each company uses at each location so that the model calculates a blended or average shadow water price for each company. Suppose a mining company used 60 per cent of its water at mine A (where the shadow price is US$10.00/m^3) and 40 per cent of its water at mine B (where the shadow price is US$2.00/m^3), the company's blended shadow price would be (US$10 x 0.6) + (US$2 x 0.4) = US$6.80.

Companies could be encouraged to disclose water use by catchment, along with the actual price paid for the withdrawals or purchased water supplies. The majority of firms only disclose information about their overall aggregate water use per annum: most do not break down water use by location. So for many companies we use proxies such as reserves for mining, installed capacity for power utilities and production data for beverages to estimate the blended shadow water price relevant to the companies' operations (for further details on this see Appendix B). Users of the tool may wish to use alternative production-related proxies to estimate the breakdown of water use by location.

The blended shadow price for each company is then multiplied by the amount of water that the company uses in a year. This calculates each company's total shadow water costs to reflect both its exposure to water-stressed areas and its dependence on access to water resources. This shadow water cost appears as a new "water opex line" on the company Profit and Loss account and thus affects the credit ratios.

Figure 4: Shadow water prices are applied to corporate water use to model financial exposure to water stress



3.3 COUNTRY-LEVEL SHADOW PRICES ESTIMATED IN THE BEVERAGES SECTOR

The model uses a slightly different methodology for beverage companies, largely because they operate so many production sites, bottling plants, distilleries and breweries around the world. So rather than trying to identify the exact location of all of these operations, their blended shadow water price is calculated at a country-level. Analysts assess the proportion of their operations in different countries, and then assign a country specific shadow price (as opposed to a locational price to the site). This approach reflects the time constraints that analysts are likely to face, but the model could be adjusted to create a more granular, site-specific evaluation in countries with significant production sites and areas of water stress.

This shadow price is then weighted according to one of the following criteria, based on a hierarchy of information:

1. How much product, in terms of hectolitres, does the company produce per country?
2. If the above information is not available, the weighting is based on the number of factories or distilleries or breweries operated per country.
3. If neither piece of information is provided, the weighting is based on the breakdown of annual revenues by country.

This simplified approach enables a high-level benchmarking on exposure to water stress. Further sub-national research could then be conducted where a company is identified as at risk from water stress. Of the eight beverages companies analysed, two firms, namely A-Busch and Heineken specify the amount of product they produce by country in terms of hectolitres. One firm, namely Nestlé, specifies the number of production sites it operates in each country. The remaining five firms break down their sales by country. For further guidance on how to use the model, see Appendix B.

Figure 5: The shadow price of water provides a risk factor to integrate water stress into credit risk analysis in water-intensive sectors

Companies analysed

Mining	Power	Beverages
Anglo American	Consol Energy	Anheuser-Busch (A-Busch)
Barrick Gold	EDF	Carlsberg
BHP Billiton	Eskom	Diageo
Fortescue Metals	GDF Suez S.A. (renamed ENGIE in June 2015)	FEMSA (Fomento Economico Mexicanos)
Glencore	RWE AG	Heineken
Rio Tinto	Sempra Energy	Nestlé
Vale	Southern Company	Pernod Ricard
Vedanta	Vattenfall	SAB Miller

PART 4: RESULTS

The model shows that many of the firms analysed in the mining, power and beverages sector operate in regions of water stress. Results of the model's application do not provide a forecast of actual impacts on the financials of specific companies or timings of costs being internalised. They provide a proxy to benchmark companies on their exposure to localised water stress across their operations worldwide, with risk aggregated at a company level so that it can be integrated into credit analysis.

Six of the mining companies analysed are investment grade and two are non-investment grade – Fortescue and Vedanta. Six of the power companies are investment grade, while two, Consol Energy and Eskom, are non-investment grade. All of the beverage companies are investment grade.[27]

Figure 6: Ratings of 24 companies from three industrial sectors, as at 17 July 2015

Sector	Company	B'berg Equity Ticker	HQ	Market Cap. Billion	Moody's	S&P
Mining	Anglo American	AAL_LN Equity	London, UK	£12.4	Baa2 Neg	BBB-
Mining	Barrick Gold	ABX_US Equity	Toronto, Canada	$10.7	Baa2 Neg	BBB-
Mining	BHP Billiton	BHP_US Equity	Melbourne, Australia	£67.3	A1	A+ Neg
Mining	Fortescue Metals	FMG_AU Equity	Perth, Australia	AUD 5.3	Ba2 Neg	BB Neg
Mining	Glencore	GLEN_LN Equity	Zug, Switzerland	£31.9	NR	BBB
Mining	Rio Tinto	RIO_LN Equity	London, UK	£47.4	A3	A-
Mining	Vale	VALE_US Equity	Rio de Janeiro, Brazil	$27.4	Baa2 Neg	BBB Neg
Mining	Vedanta	VED_LN Equity	Mumbai, India	£1.3	Ba3 Neg	BB- Neg
Power	Consol Energy	CNX_US Equity	Canonsburg, PA, USA	$4.2	B1	BB
Power	EdF	EDF_FP Equity	Paris, France	£40.2	A1 Neg	A+ Neg
Power	Eskom	1001Z_SJ Equity	South Africa	Not listed	Ba1	BB+ Neg
Power	GdF	GSZ_FP Equity	Paris, France	£43.2	A1 Neg	A
Power	RWE	RWE_GY Equity	Dusseldorf, Germany	£12.1	Baa1 Neg	BBB+ Neg
Power	Sempra Energy	SRE_US Equity	San Diego, USA	$25.7	Baa1	BBB+
Power	Southern Company	SO_US Equity	Atlanta, GA, USA	$39.9	Baa1	A Cwn
Power	Vattenfall	VATT_SS Equity	Stockholm, Sweden	Not listed	A3	A-
Beverages	Anheuser-Busch	ABI_BB Equity	Leuven, Belgium	£190.5	A2 Pos	A
Beverages	Carlsberg	CARLB_DC Equity	Copenhagen, Denmark	DKK 96.8	Baa2 Neg	NR
Beverages	Diageo	DGE_LN Equity	London, UK	£48.7	A3	A-
Beverages	FEMSA	FEMSAUBD_MM Equity	Monterrey, Mexico	MXN 512.9	NR	A-
Beverages	Heineken	HEIA_NA Equity	Amsterdam, Netherlands	£42.2	Baa1	BBB+
Beverages	Nestlé	NESN_VX Equity	Vevey, Switzerland	CHF 232	Aa2	AA
Beverages	Pernod Ricard	RI_FP Equity	Paris, France	£29.2	Baa3 Pos	BBB-
Beverages	SAB Miller	SAB_LN Equity	London, UK	£56.8	A3	A-

Source: Company Reports, Bloomberg

27. Based on data as of June 2015.

When we introduce water as a factor into the credit analysis of companies, the two parameters that determine how a firm's credit is impacted are the amount of water the firm uses, and the overall blended shadow water price that applies to the water used across the firm's sites.

Figure 7: Data on the 24 companies' water use and 2010 and 2040 blended shadow prices

Company	Sector	Water Use 2013 thousand cubic metres (m^3)	Water shadow prices 2010 $/ m^3	Water shadow prices 2040 $/ m^3	% Change between 2010 and 2040 water shadow prices
Glencore	Mining	969,000	4.33	5.41	24.9%
Rio Tinto	Mining	731,000	8.67	8.70	0.3%
EdF	Power	500,000	4.10	4.38	6.8%
Southern	Power	388,269	2.62	2.73	4.2%
Vale	Mining	373,800	1.08	1.13	4.6%
BHP Billiton	Mining	347,500	6.41	6.44	0.5%
Vedanta	Mining	344,849	2.46	3.76	52.8%
Eskom	Power	334,275	4.61	5.25	13.9%
RWE	Power	314,900	3.55	3.84	8.2%
Anglo American	Mining	201,490	1.41	1.89	34.0%
Vattenfall	Power	162,000	4.30	4.28	-0.5%
Fortescue	Mining	139,420	0.66	0.66	0.0%
GdF	Power	132,600	5.80	6.39	10.2%
Sempra	Power	120,760	8.81	8.62	-2.2%
Barrick Gold	Mining	100,909	4.16	4.55	9.4%
SABMiller	Beverages	62,100	3.24	3.68	13.6%
Nestle	Beverages	61,065	4.44	4.82	8.6%
A Busch	Beverages	39,447	4.15	4.46	7.5%
Heineken	Beverages	27,670	3.42	3.79	10.8%
Consol	Power	16,473	3.67	4.03	9.8%
Femsa	Beverages	14,950	4.67	5.38	15.2%
Carlsberg	Beverages	14,300	4.23	4.58	8.3%
Diageo	Beverages	5,581	4.56	4.95	8.6%
Pernod Ricard	Beverages	2,406	4.40	4.66	5.9%

Source: Company Reports, Bloomberg, GIZ/NCD/VfU/DBRM Associates

Figure 7 sets out the amount of water the firms used in terms of thousand cubic metres, in 2013 (column 3) and the blended shadow water prices using 2010 and 2040 scarcity for each company in 2013 (columns 4 and 5).

Together, the 24 companies use more than 5.3 billion cubic metres of water annually, almost as much as the annual freshwater withdrawals of a country like Norway (6.4 billion m^3/annum).[28] The companies are ranked in terms of the size of their annual 2013 water consumption in Figure 7. This shows a wide range in the amount of water used by the 24 companies, from Glencore, which used 969 million cubic metres (m^3) in 2013, to Pernod Ricard, which used 2.4 million m^3. Two other companies used 500 million m^3 or more in 2013 – Rio Tinto and EDF. Fifteen of the 24 firms used more than 100 million m^3 of water in 2013.

EDF is one of the top three companies in terms of water consumption. This is significant because the model only takes into account consumptive water use, while many utilities including EDF also use a great deal of water in a non-consumptive way. For example, for cooling power plants, where water is extracted from rivers or seas, run over power plants and pipes, and then returned to water courses. The model only applies shadow prices to consumptive water use, i.e. water that is not returned to the rivers or seas. None of the beverage firms directly used more than 65 million cubic metres in 2013. Beverage firms are clustered at the bottom of the ranking on water usage across the three sectors, with only the power firm Consol registering similarly low levels of water use.

Since the majority of the beverages firms' water use is through their supply chains, they may be indirectly exposed to water stress through the products that they buy (e.g. sugar, fruit, barley, packaging).[29] The model only integrates annual direct water use by companies themselves, as reported by the companies.[30] Whereas the majority of water used by mining and power companies is directly consumed in operations, direct water use may represent just 1 per cent of total water use by beverages companies. Since beverages companies do not disclose the volumes of water used by their suppliers, we have not included this in the analysis. The model excludes indirect water use because this would need to use modelled estimates based on sector averages. The analysis may therefore underestimate the level of water risk in the beverages sector.

Company-wide shadow prices calculated for the firms in 2010 (see figure 7) range from US$0.66/$m^3$ for Fortescue Metals to US$8.81/$m^3$ for Sempra Energy. Thirteen of the companies face weighted average shadow prices above US$4.00/$m^3$.

The distribution of the 2010 shadow prices within the mining sector is wide. Large mining companies such as Rio Tinto and BHP Billiton face high estimated shadow prices of US$8.67/$m^3$ and US$6.41/$m^3$ respectively, while the 2010 shadow price for Anglo American is estimated at US$1.41/$m^3$.

Beverage company 2010 shadow prices are found in the middle or towards the top of Figure 7. The 2010 shadow price range is narrow, from US$4.67/$m^3$ for Femsa to US$3.24/$m^3$ for SAB Miller. Given the large number of sites operated by beverages companies, the blended shadow prices in this sector are based on average country-level water stress data, which may mask variations in site-specific water stress within countries.

For 22 of the companies analysed, the blended shadow water price rises between 2010 and 2040. The shadow prices tend to be higher in 2040 than in 2010, because water stress and population are projected over time to rise in many locations. Water stress may be exacerbated in some regions as climate change leads to changes in rainfall patterns and more frequent and severe droughts. However, water availability is projected to increase in some locations as rainfall patterns change over time.

28. http://data.worldbank.org/indicator/ER.H2O.FWTL.K3
29. http://temp.waterfootprint.org/?page=files/Softdrinks
30. Ethical Consumer, The water footprint of soft drinks, Sector Report on the Soft Drinks Industry, 2013

4.1 SCENARIO ANALYSIS TO MODEL CURRENT AND FUTURE RISK

In our study we model the potential implications of three scenarios for the 24 companies:

1. Exposure to current water stress: firms pay the 2010 shadow prices in 2014, 2015, 2016 and 2017;
2. Exposure to future water stress: firms pay the 2040 shadow prices in 2014, 2015, 2016 and 2017.
3. Business as usual (BAU) without water stress: Companies do not face the shadow price of water.

In all three scenarios, we assume all of the companies see their annual revenues grow by 3 per cent per year, and their annual COGs (cost of goods sold) rise by 2 per cent per annum. We also assume that water use grows at 2 per cent per annum and [where applied] water prices grow at 3 per cent per annum.

Scenarios 1 and 2 model the impacts of shadow water prices on the financial ratio projections for these firms, compared to scenario 3. The firms' Net Debt/EBITDA ratios have increased (deteriorated), as they have become more leveraged; their EBITDA/Revenue ratios have fallen (deteriorated) as their margins have reduced.

Net Debt/EBITDA ratios that are estimated to be significantly exposed to the internalisation of shadow prices for water include four mining companies – Barrick Gold, Vedanta, Rio Tinto and Glencore; and the four power companies Eskom, RWE, Sempra and Southern.

Although credit ratios are important, there is no direct or one to one relationship between credit ratios and credit ratings. Credit ratios are only one part of the way in which credit analysts rate companies. Credit analysis involves financial risk analysis, looking at credit ratios, as well as business risk analysis, which involves looking at the competitiveness of an industry in which a firm operates. How strong a company's credit ratios need to be to achieve a particular credit rating depends in part on the business risks that this company faces; and this in turn is largely shaped by the industrial sector in which a firm operates.

How do the mining, power and beverages sectors compare with regards to business risk? Mining is viewed as moderately high risk, given the high level of cyclicality in the industry, and the fairly intense level of competition. By contrast, utilities tend to be low risk, due to their low level of cyclicality and natural monopoly nature of many utilities. The beverages sector lies between mining and utilities in terms of business risk, given their low level of cyclicality and low degree of competition.

Because mining firms face greater business risk than both beverages firms and utilities, mining firms need to have strong credit ratios, to have the same credit rating as either a beverage firm or a utility. In the mining space, companies probably need to have a Net Debt/EBITDA ratio of below 4.0x to be rated investment grade. A mining company would probably need a Net Debt/EBITDA ratio of below 2.0x to be rated in the Single A rating category.

In contrast, it can be assumed that power companies with Net Debt/EBITDA above 5.5x, are not likely to be investment grade, and that utilities with Net Debt/EBITDA above 3.5x are likely to be rated below the Single A rating category.

Figure 8: Estimates of the firms' net debt/EBITDA in 2017 in three scenarios

	Net Debt/EBITDA X in 2017			% in 2017 Net debt/EBITDA	
	Scenario 1: 2010 Water shadow prices	Scenario 2: 2040 Water shadow prices	Scenario 3: No Water Costs	Scen 1 vs Scen 3: 2010 Water shadow prices vs no water costs	Scen 2 vs Scen 1: 2040 Water shadow prices vs 2010 Water shadow prices
Mining					
Anglo	1.54	1.60	1.37	12%	4%
Barrick Gold	3.30	3.35	2.75	20%	2%
BHP Billiton	0.37	0.39	0.09	311%	5%
Fortescue	-0.38	-0.38	-0.44	14%	0%
Glencore	1.72	2.20	0.39	341%	28%
Rio Tinto	2.96	2.98	0.81	265%	1%
Vale	0.45	0.45	0.37	22%	0%
Vedanta	3.85	5.01	2.33	65%	30%
Power					
Consol	2.95	2.99	2.65	11%	1%
EdF	3.55	3.61	2.81	26%	2%
Eskom	27.63	35.07	9.41	194%	27%
GdF	1.23	1.25	1.04	18%	2%
RWE	2.01	2.07	1.38	46%	3%
Sempra	6.74	6.64	3.42	97%	-1%
Southern	5.54	5.62	3.95	40%	1%
Vattenfall	2.46	2.46	1.61	53%	0%
Beverages					
Anheuser-Busch	2.22	2.22	2.17	2%	0%
Carlsberg	0.36	0.36	0.27	33%	0%
Diageo	1.50	1.50	1.47	2%	0%
Femsa	2.27	2.65	0.61	272%	17%
Heinken	0.73	0.74	0.65	12%	1%
Nestle	-0.47	-0.47	-0.52	10%	0%
Pernod Ricard	1.53	1.53	1.51	1%	0%
SAB Miller	1.83	1.85	1.63	12%	1%
Average					
Mining	1.73	1.95	0.96	80%	13%
Power	6.51	7.46	3.28	98%	15%
Beverages	1.25	1.30	0.97	28%	4%
All	3.16	3.57	1.74	82%	13%

Source: GIZ/NCD/VfU Corporate Bonds Water Credit Risk Tool

4.2 MINING SECTOR ANALYSIS

When analysing which mining firms could be most impacted by water stress, the amount of water used and security of supplies are critical. Modelled impacts using the Corporate Bonds Water Credit Risk Tool show that Rio Tinto, BHP Billiton and Glencore could be most impacted by water stress, of the eight mining firms analysed, because they all use a significant amount of water and are exposed to relatively high weighted average shadow water prices.

It is worth noting that while Glencore was the largest water user in 2013, it could be less exposed to water stress than Rio Tinto, which operates in more water stressed areas and thus faces a higher water shadow water price at US$8.67/$m^3$ in 2010. Glencore benefits from the fact that its 2010 shadow price is significantly lower than Rio Tinto's at US$4.33/$m^3$; although this does rise quite sharply to US$5.41/$m^3$ in 2040.

Barrick Gold's Net Debt/EBITDA ratio could rise from an estimated 2.75x to 3.30x in 2017, if it incurs the shadow costs for current levels of water stress. Under this scenario, Vedanta's Net Debt/EBITDA ratio would rise from 2.33x to 3.85x. If the costs of water stress are internalised, according to the model, Barrick Gold could fall from its current BBB rating to High BB (non-investment grade) status. What might prevent this is the fact that even when you add water costs, Barrick Gold's EBITDA/Revenue margins remain high. Vedanta is already rated Ba3/BB-, so its rating might not change.

In 2017, Rio Tinto's Net Debt/EBITDA ratio rises to an estimated 2.96x with shadow water costs, up from 0.81x in the same year without these costs. Rio Tinto's A3/A- could be under threat: its projected leverage at the end of 2017 seems high for a Low Single A credit.

Factors such as local investment in water storage, annual fluctuations in water availability and water efficiency measures could mitigate the impact and timing of these water risks materialising. The model results suggest that further research is warranted to understand these factors and their implications for the operations of Barrick Gold and Rio Tinto. The model indicates which of their mines could be most exposed in order to focus further due diligence on relevant assets. For instance, Rio Tinto's stake in Escondida, Chile has the highest water shadow price of its assets and accounts for more than one-third of its reserves. Rio Tinto has a 30 per cent interest in the copper mine, which is managed by BHP Billiton.[31] Minera Escondida produces roughly five per cent of the world's copper, and Rio Tinto is co-financing a US$3.4 billion desalination plant at the site to be operational by 2017. Rio Tinto's US$1.03 billion investment in the plant will be funded through the company's share of Escondida's cash flows.[32] Users of the Corporate Bonds Water Credit Risk Tool can adjust the modelled shadow costs to take account of actual or projected capital or operating expenditure on maintaining water supplies where data are available.

4.3 POWER SECTOR ANALYSIS

Eskom's leverage is already extremely high, even before water costs are added, namely a Net Debt/EBITDA of 9.41 times. With current shadow water costs, this could increase to more than 27x. However, Eskom is unusual in that it is 100 per cent owned by the South African government (though its debts are not all guaranteed by the government) and the monopoly power producer in South Africa, generating over 90 per cent of the power consumed in the country. The company is short of power generation capacity in relation to peak power demand, and frequently implements "load shedding" or supply disruptions to avoid a total collapse of the electricity supply grid. Eskom is building significant new generation capacity to meet this peak demand, with US$1 billion raised through an international bond issuance in 2014 contributing to R90 billion (US$7.8 bn) in bonds planned for April 2010-March 2017.[33] Because Eskom is 100 per cent owned by the South African government, is already financially stressed and withdraws water directly from catchments, Eskom is not likely to be exposed to higher tariffs for the water it uses. The shadow water costs are more likely to be internalised through disruption to production or

31. http://www.riotinto.com/copperandcoal/escondida-4740.aspx accessed 31 July 2015
32. http://www.riotinto.com/media/media-releases-237_8934.aspx accessed 31 July 2015
33. Eskom Holdings SOC Limited. Standard Presentation. April 2015

water infrastructure costs than through water tariffs. Physical constraints on water availability can challenge the reliability of existing operations and the viability of proposed projects, imposing additional costs for adaptive measures.[34]

Eskom uses raw water that is treated before entering the production process at its coal-fired power stations. Many of its power stations are in catchments that are relatively water scarce, requiring inter-basin transfers. Many water supply schemes have been constructed to supply water to the power stations, including dams, pipelines, pumping stations and reservoirs.[35] It also faces the risk of restrictions through water-use licences for its power stations, capacity expansion programme and coal suppliers.

Sempra, RWE and Southern also see their leverages rise quite sharply, if they internalise the shadow water costs. If its credit ratios are affected by a fall in revenues or cost increases due to water stress, as modelled, Sempra Energy could see its High BBB rating fall to a non-investment grade rating: perhaps to High Double BB, because its leverage rises to 6.74x in 2017 when we use 2010 shadow costs, up from 3.42x without water stress being factored in.

Sempra's power plants that are most exposed to water stress are located in California and Arizona in the United States, and account for 73 per cent of the company's installed capacity. Southern Company's plants in Alabama, Florida and Georgia face the highest levels of water stress. In 2014, the U.S. Environmental Protection Agency (EPA) finalised regulations governing cooling water intake structures under the Clean Water Act. The Southern Company's 2014 Annual Report noted the risks that severe drought conditions can prevent the operation of certain generating facilities, and that water regulations could result in significant capital expenditure and compliance costs, with knock-on effects on cash flows.[36]

The model only analyses the consumptive use of water. By excluding non-consumptive water used for cooling in calculations, it probably underestimates the risk that water scarcity poses to power utilities. The risk that power companies could be denied access to all of the water they need for non-consumptive water purposes is a tail risk. However, droughts and heatwaves have already sparked shut downs of some power plants in the past. Users of the tool could apply a proportion of the shadow price for assets in water-stressed areas to non-consumptive water use as one way to reflect the risk that access to water may be limited in the future.

4.4 BEVERAGES SECTOR ANALYSIS

The financial ratios of the beverage firms analysed do not change greatly, largely because they do not report very large water consumption figures.

The main exception to this is Femsa, the Mexican bottling company. Femsa's Net Debt/EBITDA ratio rises to 2.27x at the end of 2017 when we include 2010 shadow costs, compared with 0.61x without water stress being factored in. Femsa also exhibits relatively weak EBITDA/Revenue margins. Although bottling firms like Femsa tend to have weaker ratios than beer or beverage production firms, Femsa's EBITDA/Revenue margin is quite small, compared to peers like Diageo and A-Busch. Femsa is rated A- by S&P. Adding the potential impact of water costs could push this down to BBB+. The concentration of Femsa's production and revenues in Mexico increases its vulnerability to local water stress, relative to more geographically diversified beverage firms.

34. International Energy Agency, Water for Energy, Is energy becoming a thirstier resource?, Excerpt from the World Energy Outlook 2012, available at http://www.worldenergyoutlook.org
35. http://www.eskom.co.za/OurCompany/SustainableDevelopment/Pages/Reduction_In_Water_Consumption.aspx, accessed 24 June 2015
36. The Southern Company (2014), Form 10-k (Annual Report) for the Period Ending 12/31/14

One way to understand and to integrate upstream water use would be to use input-output analysis to consider extraction taking place along a firm's supply chain. But we do not use input-output data here since integrating modelled sector-average data may not help to benchmark companies within sectors, and adding related estimates of water costs into company financial ratios could be over-simplifying the complexity of the pass-through of costs in supply chains. In the absence of corporate disclosures on volumes and locations of upstream water use, it is difficult to differentiate between companies that are responsibly managing their water impacts through suppliers and those that are not, in a quantitative model based on disclosed data.

4.5 IMPACT ON BONDS

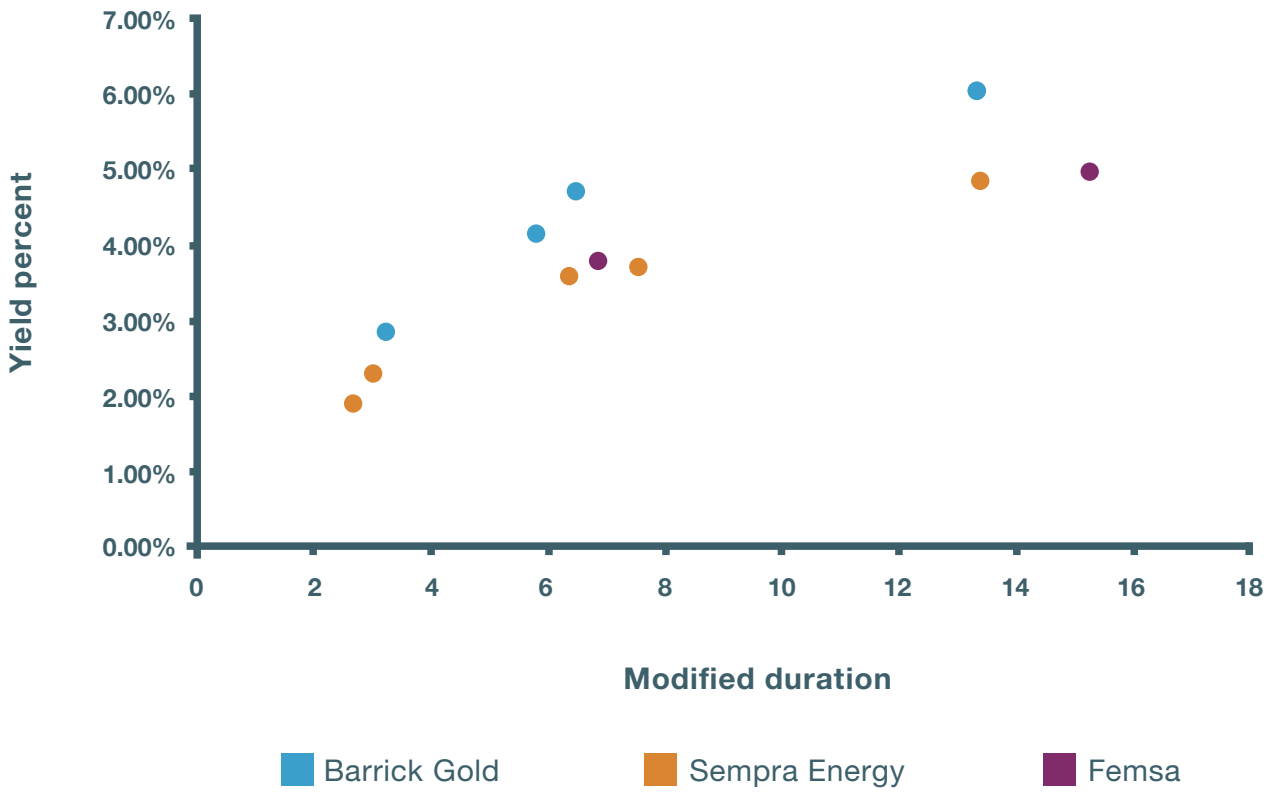
Figure 9 lists selected U.S. Dollar denominated bonds outstanding for three companies vulnerable to water risk, namely Barrick Gold, Sempra Energy and Femsa. Figure 10 charts the bonds in terms of modified duration on the x-axis versus yield on the y-axis. If water risk was translated into higher water-related expenditure or restricted access to water, these firms would be at risk of credit downgrades, and these bonds at risk of a sell-off. In a sell-off we would expect not only that the yields on these bonds would rise, but that their yield curves would steepen.

Figure 9: Selected bonds for three companies, as at 17 july 2015

Sector and Company	Coupon	Outstanding U.S. $ million	Maturity Date	Modified Duration	Yield
Mining					
Barrick Gold	6.950%	740	Apr-19	3.24	2.85%
Barrick Gold	3.850%	1,249	Apr-22	5.77	4.14%
Barrick Gold	4.100%	1,499	May-23	6.49	4.73%
Barrick Gold	5.250%	750	Apr-42	13.30	6.06%
Power					
Sempra	6.150%	500	Jun-18	2.67	1.89%
Sempra	9.800%	200	Feb-19	3.01	2.29%
Sempra	2.875%	500	Oct-22	6.36	3.58%
Sempra	3.550%	500	Jun-24	7.53	3.71%
Sempra	6.000%	750	Oct-39	13.37	4.85%
Beverages					
Femsa	2.875%	150	May-23	6.84	3.80%
Femsa	4.375%	700	May-43	15.25	4.96%

Source: Company sources and Bloomberg.

Figure 10: Selected Bonds for Three Companies, Modified Duration (X-Axis) versus Yield (Y-Axis)



Source: Bloomberg

PART 5: METHODOLOGICAL ISSUES

The Corporate Bonds Water Credit Risk Tool is based on several assumptions that give rise to methodological challenges.

Is the model double-counting?

None of the firms publish information on how much they currently pay for their water. Generally, firms do not disclose water-related costs, so it is not clear how much they already contribute to a firm's annual operating expenditure. Companies do not separate out water-related operating or capital expenditure from the rest of their assorted expenditures. Adding full shadow prices will double count some of the cost, especially where operations are in locations at which water costs are already significant. However, since water is generally under-priced, it is unlikely that the companies are anywhere close to paying shadow water costs across their entire operations.

Mining firms might use different magnitudes of water depending on what they mine?

The model uses the assumption that mining companies use water in line with the amount of reserves found at each location. However, this groups together a large range of different minerals and underground resources under "reserves". One could argue that we should in fact divide up the single "reserve" figure, and state specifically how many tonnes of each metal the company possesses. Although different amounts of water might be used in the mining of different minerals and metals, our view is that this would be too complex and would offer too little in the way of additional insights to justify in an initial analysis. Analysts using the tool could add this level of analysis to augment the credit assessment of high-risk companies.

Another approach would be to estimate the annual water use per location, based on mineral production at each site, rather than the amount of reserves. Given the flexibility of the Excel-based tool, users that have access to data on annual production by location could adjust the assumptions accordingly.

Capital expenditure to cut operating expenditure bills?

The model assumes that companies face higher water costs in full in the first year, namely 2014. But faced with these higher costs, firms in fact have various options to respond. They could:

- Accept these higher costs, reducing free cash flow
- Undertake capex to cut the amount of water they use, secure supplies or improve efficiency
- Reduce their production, so reducing the amount of water they would use

The model assumes that the company only undertakes the first option. However, according to the model, several firms analysed could face additional water opex costs of over US$1 billion per year if shadow costs were internalised. So they might consider strengthening water management to reduce their water use, or to convert saltwater to freshwater through desalination. Analysts could estimate potential efficiency gains.

A key factor here is not how much water in aggregate a company uses in a year, but how much water a firm uses at individual locations. If a firm is inland or uses a large amount of water over a large number of locations, which are geographically dispersed, then building a large water desalination plant is not likely to be viable. For high-risk companies, further research could be conducted to explore the likelihood of the costs being internalised in the near future, the companies' abilities to pass these through in higher prices, the potential capex costs of water-related technologies, corporate water strategies and local policy and governance frameworks at water-stressed locations relevant to assets.

Is the TEV framework application an ‘extreme’ approach, whereby firms are expected to internalise the social cost of water?

The TEV framework provides an estimated value to capture water stress in monetary terms, as a proxy for water risk. This can be integrated into financial analysis more readily than volumes of water use or raw geographical water stress data. The shadow price is intended to be an ‘upper bound’ with which the model is able to gauge the magnitude of direct potential exposure for a company and test the company financials against this exposure. So in that sense it is an ‘extreme’ scenario. The model does not assume that the gap between cost and value will be closed within a certain timeframe, or that actual prices paid for water will necessarily reflect the total economic value through “full cost pricing”. It would be feasible to set a lower threshold as a “mild” water risk scenario if information were available on magnitude and probability of future costs. In the absence of this information, it would be possible to test against an arbitrary threshold, such as some fraction of the TEV (eg 50 per cent). Potential future developments of the model could include intermediate threshold levels.

Further strengths and weakness of applying the TEV framework to estimate shadow water prices at locations worldwide are discussed in Appendix A.

PART 6: EXTENDING THE USE OF THE MODEL

This section explores how the model could be used to analyse other economic sectors and how other practitioners beyond credit analysts could use the Corporate Bonds Water Credit Risk Tool. These practitioners could include portfolio managers, finance professionals working within the debt capital markets divisions of banks, and corporate treasury departments.

The flexibility of the model does allow further adjustments to be made to take account of different assumptions around water risk. Examples include:

- Applying a percentage factor to the water costs if the assumption is that these will be internalised at a lower rate, or to adjust for historical water opex or capex costs already internalised.
- In the Utilities sector, a lower rate of water costs could be applied to cooling water and incorporated into the model.
- In the Mining sector, production data could be used instead of reserve data to show current exposure to water stress and allocate water use to geographical locations in proportion to historical production data.

Data on potential capex costs or water tariffs could be modelled alongside the shadow water prices to estimate the actual costs of adapting to water stress. Capex costs should take account of technology options available for each industry and their feasibility across sites worldwide. Detailed analysis could focus on the companies and sites identified as most exposed to water stress. Environmental, Social and Governance (ESG) analysts and service providers may provide support in sourcing site-level corporate data to populate the tool and to benchmark companies on financial risk.

The tool can also be extended to other sectors exposed to water risk, such as Forestry and Technology, two sectors which are potentially exposed to water stress and which issue a considerable number of bonds (technology sector issuance is a recent phenomenon). Forestry is the main source of water dependence in the pulp and paper sector, where an understanding of variations in water intensity of production at locations could be important. In the Technology sector, access to ultra-pure water at manufacturing sites and water security at component manufacturers could affect exposure to water stress.[37] And the technology sector increasingly depends on water to cool its data centres and server rooms.

6.1 DUE DILIGENCE AND RESPONSIBLE OWNERSHIP ACTIVITIES

Having identified firms “at risk”, credit analysts can undertake engagement with companies or conduct further research into issues such as local hydrological conditions, regulatory frameworks, water policies and infrastructure relevant to water scarcity.

Once an analyst has used the tool to identify at-risk companies, in any sector, results can be used for selecting companies and issues for engagement, or to follow up with further research on the company’s water management, including targets on absolute water use.

37. KPMG AZSA Sustainability Co./Trucost (2012), Companies report the primary drivers of reported risks to be physical (60%), such as water stress or scarcity or declining water quality

The UN-backed Principles for Responsible Investment's Fixed Income Investor Guide (2014) highlights water stress as one of the issues to consider in the extractive and food and beverage sectors.[38] Firms identified as potentially at risk from water scarcity using the Corporate Bonds Water Credit Risk Tool, can be asked how they are monitoring and managing these risks. Engagement activities can encourage companies to disclose information on water use in line with guidance such as the CEO Water Mandate Corporate Water Disclosure Guidelines (2014)[39] and Global Reporting Initiative G4 Sustainability Reporting Guidelines, which includes indicators on water.[40]

Analysts researching a firm's approach to water management can consult additional information sources such as the CDP water programme. CDP writes to companies in the Global 500, S&P 500 and FTSE 100 indices as well as the largest companies in Australia, Japan and South Africa, asking them questions relating to their water use. The answers supplied can provide insight into a company's approach to water policy and practice. CDP is partnering with South Pole Group to carry out a first global assessment of corporate efforts to tackle water security at 700 of the world's largest companies operating in 112 countries across the most water-dependent industry sectors, using a public scoring methodology to evaluate and benchmark corporate water management.

Beyond credit analysts and portfolio managers, this tool might also be useful to bond professionals working in origination and syndication. They could use it to analyse the potential impact of water scarcity on their issuer before they bring bonds to the market or even before they talk to companies about their issuance needs.

Companies themselves might use the tool to consider the potential impact of water stress on credit ratings. They would be well placed to use the tool as they should be able to source good data on water usage, the location of their operations, water prices, and data about capex responses to higher water prices.

Credit risk managers, who tend to focus on large portfolios of bonds, rather than on individual bonds could find the model useful for those analysing whole portfolios of bonds.

Another application of the tool could be to identify financial opportunities to mitigate water risk through the issuance of "green water bonds" for water-related investments in line with the forthcoming standard from the Climate Bonds Initiative.[41]

6.2 NEXT STEPS

GIZ and the NCD are developing a joint project to build on the Corporate Bonds Water Credit Risk Tool to explore options to advance banks' environmental stress testing of lending portfolios. This will focus on potential water scarcity impacts under science-based climate scenarios and aims to build capacity for banks to evaluate exposure to economic risk from drought in loan books, focusing on emerging markets. The project will develop guidance for financial institutions to strengthen risk management systems in order to better prepare for water shocks and develop more advanced approaches to monitoring exposure to related financial risks at a portfolio level. To find out more, contact secretariat@naturalcapitaldeclaration.org

38. Principles for Responsible Investment (2014). Corporate Bonds, Spotlight on ESG Risks
39. http://ceowatermandate.org/files/Disclosure2014.pdf accessed 24 June 2015
40. https://www.globalreporting.org/Pages/default.aspx accessed 24 June 2015
41. http://www.climatebonds.net/standards/water accessed 29 June 2015

CASE STUDY: Embedding water risk in portfolio risk management frameworks

Lynn Connolly, Founder of Harbor Peak, a provider of risk management, research and due diligence advisory services for environmental impact investing, tested how the water shadow price used in the Corporate Bonds Water Credit Risk Tool could be integrated into portfolio risk management models to evaluate and manage their corporate bond portfolios' exposure to current and projected pressure on water resources, and the resulting impact on projected corporate bond yields. This box summarises the resulting working paper, *"Defining the Water Risk Factor for use in Portfolio Risk Management models and Risk Factor Portfolio Asset Allocation"*.

Water is a financial risk to firms and corresponding investment products. Asset managers and financial institutions can include the new "water risk" factor in their risk management models used in the risk analysis of all asset classes, and in portfolio asset allocation where portfolios are constructed to offer diversification over "risk factors" rather than asset classes.

One of the main goals in defining a water risk factor or variable that contributes to the risk and/or return of a particular asset or asset class is that it can be easily incorporated into most of the risk management platforms currently in use. The challenge lies in designing the water risk factor in such a way that it is meaningful and can be effectively calculated, so that risk management models can analyse the additional data quickly and efficiently.

Using the Corporate Bonds Water Credit Risk Tool initial shadow water price valuation as the baseline and a multi-factor model for an example of risk management analysis, the water risk factor can be adjusted based on various market and idiosyncratic risks using a weighting approach which could also be utilised for stress testing and scenario analysis. The water risk factor can be viewed as a "sensitivity" score incorporating both market and company-specific components for individual security and portfolio analysis. Basically, the water risk factor is the current and projected price and corresponding usage of water and the resulting impact on the financial/economic condition of the firm. However, the price of water and the firm's water use requires several variables, many which are currently estimations.

As risk managers require a way of easily incorporating and comparing water risk across individual securities and portfolios, the shadow water price valuation can be used to set the baseline, and then the portfolio risk manager can assess the water risk factor by a subjective weighting approach as to the likelihood and degree of impact of market and idiosyncratic influences on the valuation and/or sensitivity of the water price/economics vis a vis the company.

There is also a forward measure component to the water risk factor which would traditionally entail a regression model for determining the volatility of the measurements based in part on historical information. However, due to the limited historical data on detailed water usage, this would also be a subjective measurement. In addition, the selection of models that account for non-linearity may be most useful to determine volatility. Once the water risk factor is determined, it is important to construct co-variance matrices between individual securities within the portfolio and further adjustments to the water risk factor may be required.

Although there is limited data currently available, a water risk factor can be defined utilising a sensitivity scoring/weighting approach, with varying subjectivity, for use in portfolio risk management and risk factor portfolio asset allocation, to determine at what level there may be an impact on bond yields and risk of default.

In addition, separating the water risk factor into components, both market risk and company based risk, allows for a greater flexibility in adjusting these components and determining the resulting impacts on the overall portfolio and individual securities. This also allows for more dynamic stress testing, in addition to more flexible comparative analysis.

For example, this may highlight a high correlation amongst securities in the portfolio utilising the same water basin, which an asset manager may want to reduce through diversification. This will also give the risk manager a better understanding of the interdependencies within the corporate bond portfolio and other risk factors. Furthermore, once the water risk factor is incorporated and the impact on the portfolio better understood, triggers can be set which would give indications to the risk manager of potential changes to the water risk impact. This would allow the risk manager to gain a sense of possible "trends" and make adjustments before potential material impacts occur.

To find out more about how a water risk factor can be defined and incorporated into a risk management framework currently in place, see http://www.harborpeak.com/Research.html

APPENDICES

APPENDIX A: GEOSPATIAL DATA AND THE TOTAL ECONOMIC VALUE (TEV) OF WATER

The geospatial information on water stress is sourced from the World Resource's Institute's Aqueduct Water Risk Atlas. The model only draws on Aqueduct water stress data.

Aqueduct is a publicly available global database and interactive mapping tool to provide information on water risk. It includes Intergovernmental Panel on Climate Change data on projected changes in water availability worldwide in 2020, 2030 and 2040.

The Aqueduct model defines baseline water stress as the ratio of total annual water withdrawals to total available annual renewable supply. Baseline water stress is measured between 1 and 5, as set out here:

Baseline Water Stress Score

0-1 Low (<10%)
1-2 Low to Medium (10-20%)
2-3 Medium to High (20-40%)
3-4 High (40-80%)
4-5 Extremely High (>80%)

To find out more about the methodology and data sources used by the WRI, see http://www.wri.org/sites/default/files/Aqueduct_Global_Maps_2.1.pdf

Shadow Water Prices – applying the TEV framework to analyse water stress

The joint GIZ/NCD/VfU project has delivered an open-source, stand-alone tool for users to source shadow prices that reflects local levels of water scarcity for each longitude and latitude, so that they can apply these values to quantities of water used at sites worldwide and factor current and projected resource constraints into financial analysis and decision-making.

An environmental economics approach known as the "total economic value" or TEV framework, was used as the basis for estimating the wider value of water as an indicator for water scarcity. This approach takes account of alternative uses of the natural resource, including the external benefits that water provides to society and the environment, in addition to the private benefit gained by water consumers.

The methodology to develop the shadow water price has been independently peer reviewed by an Expert Council in the GIZ/NCD/VFU project. NCD Signatories and Supporters were consulted on a draft paper outlining the approach to delivering the first open source dataset and methodology for water valuations globally that are publicly available.

Explaining the Hybrid Function Used to Estimate the Shadow Price of Water

A 'hybrid' function was used to estimate the shadow price of water – an equation with two inputs (independent or explanatory variables) and four outputs (dependent variables), all relating to a specific location.

Independent Variables

Baseline water stress (BWS) is calculated in terms of water withdrawals (demand) versus water availability (supply) at any 10km by 10km area of the globe. This 'raw' water stress ratio is then translated into a water stress 'score', which ranges between 0 and 5. Both the water stress raw and score data are provided by the World Resources Institute.

Population is considered in terms of the number of people within 50 kilometres of a location. Rather than using absolute population numbers in the function, a weighting for different population sizes (<1,000, <10,000, <100,000, etc.) within 50 kilometres is applied in the function. Applying a population weight provides an indicator for potential competition for resources. Population data was sourced from the Global Rural-Urban Mapping Project (GRUMPv1), provided by the Socioeconomic Data and Applications Centre (SEDAC), located at the Centre for International Earth Science Information Network (CIESIN) of Columbia University, NY. (http://sedac.ciesin.columbia.edu). A population weighting was applied in the following order:

Population	Weighting
< 1,000	0.1
1000 – 10,000	0.5
10,000 – 100,000	1
100,000 – 1,000,000	1.5
> 1,000,000	2

Dependent variables

The four dependent variables in the equation (the four components of shadow water price) are:

i) agricultural values
ii) domestic supply values
iii) human health impacts and
iv) environmental impacts.

In our analysis, water not consumed by a company could be used for agriculture; to supply the domestic water network; to promote human health; and by the natural environment.

Each dependent variable is valued in terms of US$/m^3. We add together these values to come to a shadow price, in US$/m^3, for each location considered, as follows:

TEV = agricultural value
+ domestic supply value
+ human health impact
+ environmental impact

All four dependent variables are a function of W (baseline water stress) but only three (domestic supply value, human health and environmental impact) are a function of population. We make this distinction because we assume that agriculture (irrigation) is a consumptive user of water, while the use of water for domestic supply, human health and environmental services is non-consumptive. Because agriculture uses water in a consumptive fashion (once used, it is 'gone' and cannot be used again) the value of water for agriculture does not depend on the number of people nearby. By contrast, the value of human health, environmental impact and domestic supply will be higher, the larger the number of people near a location.

The human health dependent variable includes the term D, standing for DALY or 'disability adjusted life years', per m^3 of water consumption. This metric was launched by the World Health Organisation as a measure of the global burden of

disease. Consider DALY as a lost year of 'healthy life', through disease due to poor sanitation or malnutrition from water scarcity. The DALY value is a constant. Value estimates for DALY range from US$5,000 to >US$100,000, and depend on life expectancy, discounting and other factors. We adopt a DALY value of US$50,000 but this is user adjustable.

Each dependent variable is valued in US$/m^3 and summed to estimate the shadow price for each location considered.

Why do we call this a hybrid equation?

We describe this equation as a "hybrid" because the four dependent variables are calculated in different ways. The agricultural value is calculated using a 'meta-analysis'. By meta-analysis, we mean that we use estimates of value of agricultural water use from published research, to infer values for agriculture at new locations.

The values for human health and environmental impacts are calculated using life-cycle impact factors developed by Pfister et al (2009). Life cycle analysis is a technique to assess the environmental aspects and potential impacts associated with a product, process, or service, by compiling an inventory of inputs and environmental releases and evaluating related potential environmental impacts to inform decisions. The values for domestic supply are calculated on a simple assumption that value increases with water scarcity (figure 11).

Figure 11: Explanation of the dependent variables in our TEV calculation

Dependent variable	Water Use Considered to Be…	Equation	Independent Variables Impacting Dependent Variable	Method for Calculating
Agricultural value	Consumptive	(2W/5)	Baseline water stress	Meta-analysis based on estimates of value of agricultural water use from study sites in published research, to infer values for agricultural water use at new locations ("benefits transfer"). To minimise variation across methods and significant uncertainty in values normalized across years for inflation and pricing parity, the search was restricted to studies published from 2000 to 2015.
Domestic supply price	Non-consumptive	P (4/5(W+1))	Baseline water stress Population	The values of domestic supply are calculated on an assumption that value increases with water scarcity, with values ranging from US$0/m^3 to US$5/m^3. Values are based on the range of urban prices in the Global Water Intelligence 2014 tariff survey data
Human health	Non-consumptive	PD (2 x 10^{-8} x W^2 + 10^{-8} x W+ 10^{-7})	Baseline water stress Population	Calculated using life-cycle analysis impact factors developed by Pfister et al (2009). Includes a value for 'disability adjusted life years' (DALY), per m^3 of water consumption.
Environmental impact	Non-consumptive	P (W/10) x (0.031W^2 + 0.015W)	Baseline water stress Population	Calculated using life cycle analysis impact factors developed by Pfister et al (2009).

Source: Own Analysis

W = BWS score
P = Population weight
D = Value of DALY (disability adjusted life year)

Results, strengths and weaknesses

As water can be used for a variety of purposes (for example, agricultural production, industrial production, municipal supply to households, fisheries habitat or environmental flows), there are different values for different uses. In estimating a shadow price for water, we aim to identify a volumetric average value (US$/m^3) across all these potential uses. This is inevitably a simplifying approach, and dependent on the spatial precision of available data.

The field of meta-analysis and benefit transfer is an evolving area in environmental economics. The meta-analysis approach applies a formula to estimate the value of water, based on a review of published valuation studies which largely focus on water for agricultural use; hence it provides only a partial representation of Total Economic Value. The value derived for a specific location based on meta-analysis of existing studies was "transferred" to other locations with similar characteristics, in this case water scarcity.

Where scarcity data is available for new locations of interest, the value function is used to estimate a local value (or shadow price). The value of water is highly site-specific, depending

on a number of factors including local supply and demand, quality, timing and reliability of supply, as well as local demographic and other factors.

The population weighting does not take account of whether water users are upstream or downstream. The weightings applied are non-linear and arbitrary, but intended to provide insight into the higher potential values of water where local population is higher. A more comprehensive assessment of individual component values could take into account different degrees of consumptive use, or use more precise population adjustments. Furthermore, this approach does not estimate individual values per person (as might be estimated through a willingness-to-pay survey, for example).

Environmental impact factors are measured as an 'area of ecosystem damage', in m^2 per m^3 of water consumed, based on an estimate of value to ecosystem damage. There is a large degree of complexity and uncertainty in combining hydrological modelling with predictions of ecological change and estimates of economic value. For the global analysis, a range of values was applied to increase with water scarcity from US$0-0.50. This is a conservative estimate, given that the range of published estimates range from US$0.05-US$1.80/m^3 of water.

The shadow water price does not take account of water quality issues, which are complex and were outside of the scope of the analysis. Costs associated with corporate water pollution, treatment and related penalties can be significant and incorporating water quality into financial analysis would further enhance credit analysis risk assessments. The NCD work programme will explore the potential to develop such methodologies in the future.

APPENDIX B: GUIDANCE ON USING THE TOOL

The Corporate Bonds Water Credit Risk Tool can be downloaded from http://www.naturalcapitaldeclaration.org bonds-water-scarcity/

How to use the Tool

The Corporate Bonds Water Credit Risk Tool takes the form of a single Excel file. It is prepopulated with the financial, locational and shadow price information for 24 companies grouped by sector: mining (8.0-15.0), power (16.0-23.0), then beverages (24.0-31.0); where each firm is analysed on a separate sheet. However, before one arrives at the company sheets, the user is presented with seven sheets (1.0 to 7.0) providing information on the tool and a results summary. The tool is designed so that new sheets can be added where new firms are analysed; see 'How to Add New Companies to the Model' below.

Figure 12: Description and purpose of sheets in corporate bonds water credit risk tool

Sheet No.	Purpose
1.0 Guidance	Lists and explains the purpose of different sheets.
2.0 Companies	Lists the 24 companies analysed in the model. Information on each firm is presented, including its company's headquarters, market capitalisation, Bloomberg equity ticker, and credit rating with Moody's and S&P.
3.0 Sum Ratios	Summarises EBITDA/Revenue and Net debt/EBITDA ratios for the 24 firms. On the left-hand side of the sheet, static credit ratios are presented, assuming that companies do not face water shadow prices. On the right hand side ratios are drawn from the individual company sheets; as the analyst adjusts the assumptions made on any or all of the company sheets, so the resulting ratios are shown. The analyst can compare ratios generated when firms face no shadow water costs [Left-hand side of the sheet] with the ratios faced under the water risk assumptions [Right -hand side].
4.0 Graph Ratios	Analysts can graph data from any of the firms in the model. The model allows analysts to see how elements of a firm's operation change over time.
5.0 Graph Financials	Shows the effect of 2010 shadow prices on company financials. Using the dropdown menu "select company sheet", analysts can select a firm included in the tool and then use the dropdown menu "select graph item" to choose a financial indicator.
6.0 New Company	Where analysts enter a new company. Data on locations and longitude/latitude is automatically included in the "New Co Location Data" tab [33.0] where water stress data is sourced from the WRI's Aqueduct Water Risk Atlas and shadow prices are calculated.
7.0 Blank	For analysts' own workings.
8.0 to 31.0	Pre-populated sheets with analysis of 24 companies.
32.0 Location data	Data for the 24 companies analysed by the model are held on the sheet. Data are pulled in from the World Resources Institute onto this sheet, using a macro.
33.0 New Co Location Data	New location data: this links to the "New Company" tab [6.0]; a macro pulls in water stress data at a catchment level from WRI's Aqueduct Water Risk Atlas for each location. It includes a formula to calculate the shadow price for each of these locations, which is then displayed on the "New Location" tab alongside the locational information at the bottom.
34.0 Country data	This sheet calculated 2010, 2020, 2030 and 2040 shadow prices for countries, as opposed to for specific locations. This was necessary as we use country-level shadow prices for the beverages sector.

Usage of the Corporate Bonds Water Credit Risk Tool and methodology

The project developers would appreciate information on whether and how financial institutions and service providers are using the Corporate Bonds Water Credit Risk Tool, and any outcomes of its application. To share this information, provide feedback or if you have any difficulties in using the tool, please contact secretariat@naturalcapitaldeclaration.org

How the Model Evaluates Corporate Exposure to Water Credit Risk; Sheets 8.0 to 31.0

The upper part of each sheet contains a conventional credit model

All of the individual 24 sheets that model the 24 firms have the same layout as one another. The top half of each Excel sheet is a standard credit analyst company model. The top half of the model contains profit and loss (P&L), cash flow and balance sheet information for each company, for the years 2013 to 2017. While there are some differences in the way P&L information is presented, the formats of the cash flow and balance sheet is consistent for all firms.

Financial jargon

EBITDA: Earnings before Interest, Tax, Depreciation and Amortisation.
FFO: Funds from Operations. FFO is essentially EBITDA minus cash interest and cash tax (interest and tax items from the firm's cash flow).

These three statements are interlinked. The profit and loss account is connected to the cash flow statement, because the firms' EBIT figure is taken from the P&L and entered onto the firm's cash flow. The cash flow statement is connected to the balance sheet statement in that the free cash flow after dividend figure for 2013 is added to the end 2013 cash and short-term securities figure, so impacting the end 2013 net debt figure.

These three statements generate five credit ratios displayed on rows 30 through to 34: gross debt/EBITDA, net debt/EBITDA, FFO/net debt, FFO/gross debt and EBITDA/revenue.

The lower part of each sheet contains data on water consumption and locational shadow water prices

The lower part of each company sheet is the novel feature of this model. Here we introduce location-specific information about the firms' operations and water use, and calculate the company-specific shadow water costs to link water use and water stress data. From rows 43 to 46, information is presented on the amount of water that a company used in 2013, in terms of thousand cubic metres. We enter the aggregate water used in 2013 for each company. We gather this data largely from Bloomberg, which gathered this information from companies' annual or corporate responsibility reports. The water use figure is calculated differently for different sectors. Below we set out the Bloomberg mnemonics used to calculate water use by firms in different sectors.

Figure 13: Different Bloomberg water use devices by sector

Sector	Bloomberg devices to calculate water use, by sector
Power companies	Subtract the COOLING WATER OUTFLOW figure from the COOLING WATER INFLOW figure, to arrive at a Water Use figure
Mining companies	Subtract TOTAL WATER RECYCLED from TOTAL WATER USE, to calculate Total Water Withdrawn
Beverage firms	Add SURFACE WATER WITHDRAWALS, GROUND WATER WITHDRAWALS and MUNICIPAL WATER USE to calculate Total Water Withdrawn

For each location around the world, the model pulls in data on current and projected water stress held by the World Resources Institute (WRI) and uses this to calculate shadow water prices (see Appendix A) for the years 2010, 2020, 2030 and 2040. The blended current shadow water price for each company is presented on row 48. From rows 63 and below, information is presented on the main locations at which the firm operates. We present the name of these locations in column A, and the latitude and longitude, to two decimal places, in columns B and C. We also calculate the amount of water used at these locations.

Most firms only provide data for their overall aggregate water use per annum: most do not break down water use by location. So for most companies, we make assumptions about how much water they use by location, per annum, in the following way: For **mining companies**, we divide up their annual water use, in proportion to the size of the firm's mining reserves at each location. So if mine A has 60 per cent of a company's reserves and

mine B 40 per cent, we assume that 60 per cent of the water is used at mine A and 40 per cent at mine B.

For **power companies**, we divide up their annual water use, in proportion to the size of the power generation installed capacity in megawatts (MWs) at each site. So if a firm has two sites with 400 MW of generation capacity at each, then we assume each site uses 50 per cent of the firm's annual water usage.

For **beverage companies**, we look at the number of factories each firm has in each country. Because many beverage firms have so many factories, we look at country level rather than locational water TEVs. We work out what percentage of a beverage firm's factories are in each country, and then calculate the firm's blended water costs in terms of national shadow water prices, based on national baseline water stress scores provided by the World Resources Institute (WRI).

The model uses a slightly different methodology for beverage companies, largely because they operate so many production sites, bottling plants, distilleries and breweries around the world. So rather than trying to identify the exact location of all of these operations, their blended shadow water price is calculated at a country-level. Analysts assess the proportion of their operations in different countries, and then assign a country specific shadow price (as opposed to a locational price to the site). This approach reflects the time constraints that analysts are likely to face, but the model could be adjusted to create a more granular, site-specific evaluation in countries with significant production sites and areas of water stress.[42]

How then do we get the appropriate average shadow water price for each beverage firm? We assign a weighting to the country shadow water price according to one of the following criteria. Essentially we look at the following hierarchy of information provision.

- How much product, in terms of hectolitres, produced per country, does the company produce? If disclosed, this information is used to assign weightings to the different country shadow prices.
- If the above information is not available, the model includes the number of factories, bottling plants or distilleries or breweries they operate per country to develop a weighting for the shadow price.
- If neither piece of information is provided, the breakdown of the company's annual revenues by country is used.

Of the eight beverages companies that we analyse in this report, only A-Busch and Heineken specify the amount of product they produce by country in terms of hectolitres. Nestlé specifies the number of production sites it operates in each country. The remaining five firms break down their sales by country.

Having divided up the water use of the company in any year between its operational plants, we then allocate the estimated shadow price of water to each site in the mining and power sectors. For the beverage companies, the model applies a blended water cost that is based on the overall water scarcity of the countries in which the companies operate.[40]

The model calculates shadow prices for water as US$/m^3, for every land-based location around the world. A blended shadow price is calculated for each company by considering the amount of water used at each location to weight the shadow prices at each site. So for the mining company that used 60 per cent of its water at mine A (where the shadow price was US$10.00/m^3) and 40 per cent of its water at mine B (where the shadow price is US$2.00/m^3), the company's blended shadow price would be (US$10 x 0.6) + (US$2 x 0.4) = US$6.80.

The blended shadow price that the company faces is multiplied by the amount of water that the company uses in a year. This sum is integrated into the financials as a new water opex line on the company profit and loss account. Entering this sum has a negative impact on the company's credit ratios. Users may use the analytical results to consider whether the estimated ratios deteriorate sufficiently for the company to be at risk from a credit rating downgrade.

42. WRI provided country-level water scarcity data for 2010. The NCD commissioned WRI to estimate country-level baseline water stress values for the years 2020, 2030 and 2040.

Analysts are able to alter four different assumptions of the model

1. In column B row 37, they enter their assumption of the annual revenue growth, in percentage terms.
2. In B 38 they enter their assumption about the annual rate of growth of cost of goods sold, in percentage terms.
3. In B 39 they enter their assumption about the annual rate of growth in water use.
4. In B 40 they enter their assumption about the average rate of growth of the price of water.

How to Add New Companies to the Model

Users can add information on new companies to analyse in the tool.

To enter new companies to analyse in the tool:

1. Select the "6.0 New Company" sheet. Copy the 6.0 New Company sheet, and save as a new tab; with the name of the company being entered.
2. Enter financial data for the new company on the top half of this new sheet.
3. Enter latitude and longitude data for the company's main locations on the lower half of this sheet. Analysts can find the latitude and longitude of these main locations, by entering the location's name and country into the appropriate box on the first page of the NASA web site: **http://mynasadata.larc.nasa.gov/latitudelongitude-finder/**. A hyper link to this website address is included at the top left of the 33.0 New Co Location Data [and at the top left of the 32.0 Location Data sheet]. The user can access the NASA website on that page or by typing the website address in any browser. This website provides the latitude and longitude of an address, and a satellite picture of the site.
4. Once the analyst has entered the key locations and their latitudes and longitudes, he or she should press the "PROCESS COMPANY DATA" button found on the 6.0 New Company sheet. Pressing this button will pull in the appropriate water stress data from the WRI Aqueduct Water Risk Atlas, and calculate the shadow water prices (2010, 2020, 2030 and 2040) relevant to water stress levels at these locations.
5. The user needs to enter information on water use by location or on reserves/installed capacity/production/sales/number of factories by location in order to weight the shadow price values by the relevant factor.
6. The weighted shadow prices should show in the section "Water pricing and consumption", where total company-wide water usage can be entered to apply the relevant blended shadow price for the specific company.
7. "Additional water opex" will appear in row 7 so that the potential impact on financial ratios can be assessed.
8. Analysts can add modelling of additional water capex costs in row 21, and adjust assumptions about revenue growth, COGS, water use growth and water price growth per annum in rows 37-40.

Frequently Asked Questions About the Tool

What happens if the 'macro' on the Location sheet does not pull in the data nor calculate a shadow water price?

This is normally because the latitude and longitude chosen by the NASA website is located too close to the sea (or a lake), meaning that no reading is given. This can be a repeated problem for power companies that locate their power plants by the sea. If the website generates no reading, we suggest that the user slightly alters the Latitude and Longitude readings to record a reading slightly further 'inland'. This can be done in conjunction with the satellite image provided by the NASA website.

What if the NASA website produces the Longitude and Latitude of the wrong location?

This happens occasionally. For example, if one enters the name of a rural region, the NASA website might bring up a road by the same name, in an urban area. To overcome this problem, check the satellite image that accompanies each location. One can zoom in and zoom out on

this satellite image, to check that the location chosen by the NASA website is the right one, in the right location.

Where can users of the Tool find corporate data on locations and water use?

Company financial reports and websites often include data on the location of assets, production and financial data. Websites or sustainability/integrated/corporate social responsibility reports often include a figure on company-wide water use. In the absence of site-level data on water use, analysts may wish to use a sector-specific hierarchy of proxy data to estimate the site-level breakdown of water use. For instance, the model uses reserves data for mining, installed capacity for power utilities and production, and number of operations or revenue for the beverages sector.

How are the country-level baseline water scores calculated for 2010, 2020, 2030 and 2040?

The World Resources Institute used three spatially explicit inputs for its weighted aggregation analysis: source indicators, gridded weights, and target regions. Baseline water stress was chosen as the only source indicator, as it provides an effective measure of the demand and depletion of water resources based on the ratio of water withdrawals to available supply. Total water withdrawals were used as gridded weights in order to indicate where industrial, domestic and agricultural water demand takes place. Both of these datasets were available from Aqueduct Water Stress Projections Data for future years[43] and Aqueduct Global Maps 2.1 for current conditions. For future projections, water stress and total water withdrawal data were based on "business-as-usual" climate and socioeconomic pathways, namely Representative Concentration Pathway (RCP) 8.5 and Shared Socioeconomic Pathway (SSP) 2.[44] For each target region, a mean baseline water stress score was computed. The weighted average methodology followed that of Aqueduct's weighted aggregation of spatially distinct hydrological indicators.[45] Within each administrative region, sub-catchment level water stress was resampled into grids to match the cell size of the total withdrawals data. The weighted average was then computed by multiplying the resampled source indicator grids by the weighting grids, summing, and dividing by the sum of the weighting grids across the target region. To find out more about Aqueduct data, see http://www.wri.org/our-work/project/aqueduct

43. WRI provided country-level water scarcity data for 2010. The NCD commissioned WRI to estimate country-level baseline water stress values for the years 2020, 2030 and 2040.
44. Natural Earth Data. 1:10m Admin 0 - Countries. Accessed on 1/23/14, available online at http://www.naturalearthdata.com/
45. http://www.wri.org/sites/default/files/aqueduct_coutnry_rankings_010914.pdf accessed 12 August 2015

C: BLOOMBERG WATER RISK VALUATION TOOL (WRVT)

The Bloomberg WRVT, co-developed with the NCD, is a practical, high-level demonstration tool that illustrates how water risk can be incorporated into company valuation in the mining sector using familiar modelling techniques. The methodology can also be adapted and applied to other relevant sectors, and refined to support the creation of plug-and-play tools for market participants. It is available on the Bloomberg Terminal. An open-source version of the tool requires corporate data to be added in order to function effectively.

Comparing the water tools for equities (Bloomberg WRVT) and GIZ/ NCD/VfU Corporate Bonds Water Credit Tool

Common elements

- World Resources Institute's Aqueduct Water Risk Atlas data on water quantity, including projected changes in water supply, water demand, water stress and seasonal variability under scenarios for climate and economic growth.
- Shadow prices can be used as a proxy for water risk.
- Functionality to evaluate company-level water risk and benchmark companies against peers.

Figure 14: Differences between the water risk tools

	Bloomberg/NCD Water Risk Valuation Tool	GIZ/NCD/VfU Corporate Bonds Water Credit Risk Tool
Asset class	Equities	Corporate bonds
Financial ratios	Equity focus (DCF)	Fixed income focus (credit risk)
GICs Sectors/ sub-sectors	Gold and Specialist Metals & Minerals	Diversified Metals & Mining, Electric Utilities, Beverages
Companies analysed	Stock exchange listed pure-play gold and copper producers	24 major issuers in the U.S. and Euro denominated bond markets
Corporate data sources	Bloomberg	Bloomberg, CDP and company reports
Open source elements	Model with functionality of tool will be publicly available with option to add corporate data.	Tool with analysis of 24 companies benchmarked within sectors (pre-populated with NCD research & analysis).
Availability	Bloomberg and NCD/UNEP FI websites.	NCD/UNEP FI/GIZ/VfU websites
Time horizon for projected changes in water scarcity	2010, 2020, 2030	2010, 2020, 2030, 2040

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Natural Capital Declaration (NCD), GIZ and the German Association for Environmental Management and Sustainability in Financial Instimtions (VfU) have developed a Corporate Bonds Water Credit Risk Tool to enable portfolio managers and analysts to evaluate corporate bond exposure to water stress. The tool has been developed and tested with seven banks and fund managers across Europe, the U.S. and Latin America. This report includes key findings from applying the tool across 24 mining, power and beverages companies, along with guidance on using the tool. The project was commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ).