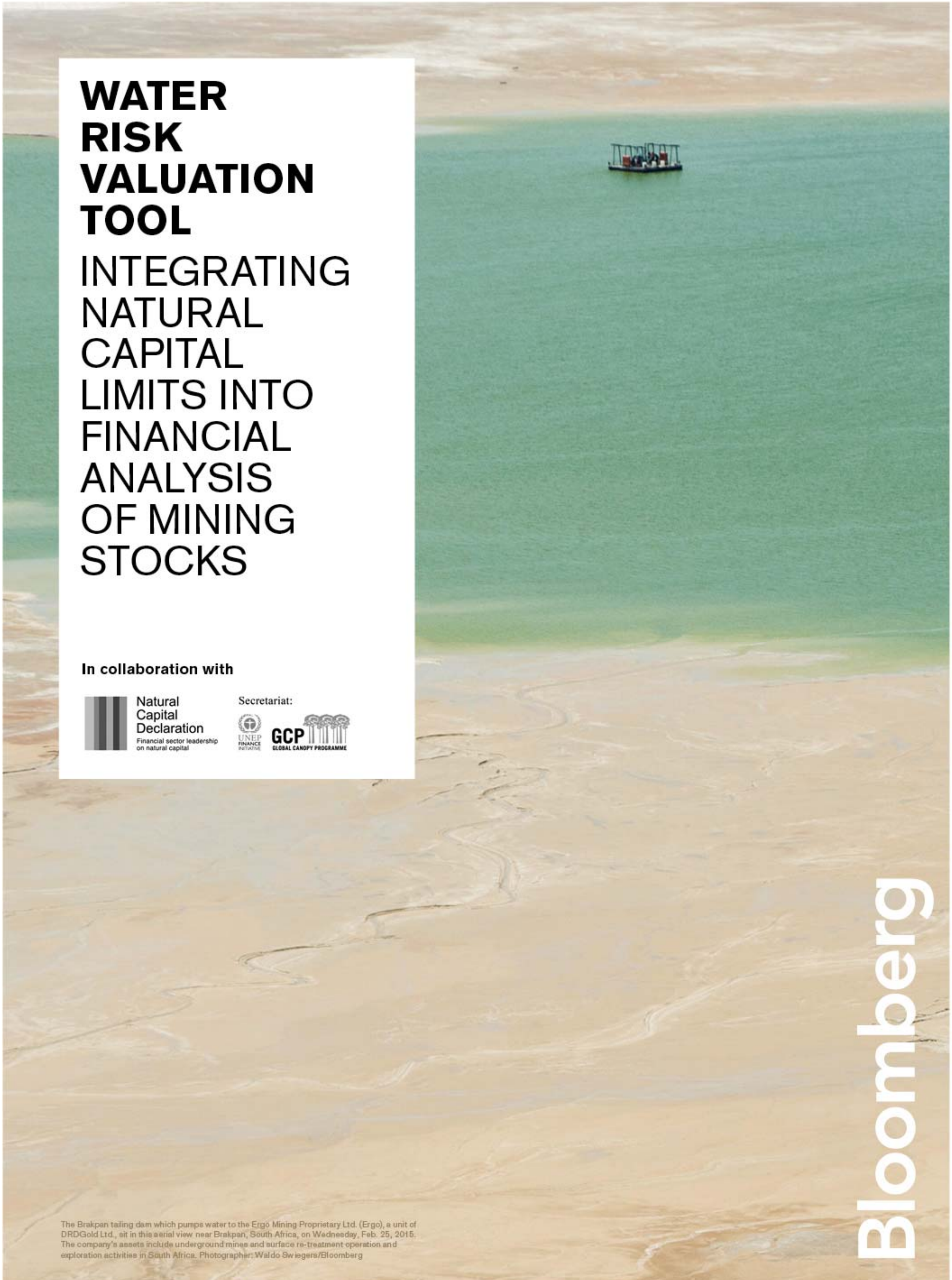
WATER RISK VALUATION TOOL

INTEGRATING NATURAL CAPITAL LIMITS INTO FINANCIAL ANALYSIS OF MINING STOCKS

In collaboration with

Natural Capital Declaration
Financial sector leadership on natural capital

Secretariat:
UNEP Finance Initiative
GCP Global Canopy Programme



The Brakpan tailing dam which pumps water to the Ergo Mining Proprietary Ltd. (Ergo), a unit of DRDGold Ltd., sit in this aerial view near Brakpan, South Africa, on Wednesday, Feb. 25, 2015. The company's assets include underground mines and surface re-treatment operation and exploration activities in South Africa. Photographer: Waldo Swiegers/Bloomberg

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ACKNOWLEDGEMENTS

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THE NATURAL CAPITAL DECLARATION

The Natural Capital Declaration (NCD) was launched at the UN Conference on Sustainable Development (Rio+ 20 Earth Summit) in 2012 by the UN Environment Programme Finance Initiative (UNEP FI) and the non-governmental organization, Global Canopy Programme (GCP). The NCD is a worldwide finance-led initiative with commitments to integrate natural capital considerations into financial products and services, and to work towards their inclusion in financial accounting, disclosure and reporting. The NCD is endorsed by more than 40 financial institutions. Signatory financial institutions are working towards implementing the commitments in the Declaration, including through NCD projects to co-develop practical methodologies, tools and guidance to build capacity. These are overseen by a steering committee of signatories and supporters and supported by a secretariat formed of the UNEP FI and GCP.

GCP is a UK-based tropical forest think tank working to demonstrate the scientific, political and business case for safeguarding forests as natural capital that underpins water, food, energy, health and climate security for all. GCP works through its international networks – of forest communities, science experts, policymakers, and finance and corporate leaders – to gather evidence, spark insight, and catalyse action to halt forest loss and improve human livelihoods dependent on forests. The Global Canopy Programme is a registered UK charity, number 1089110.

UNEP FI is a unique global partnership between the United Nations Environment Programme (UNEP) and the global financial sector. UNEP FI works closely with over 200 financial institutions who are Signatories to the UNEP FI Statements, and a range of partner organizations to develop and promote linkages between sustainability and financial performance. Through peer-to-peer networks, research and training, UNEP FI carries out its mission to identify, promote, and realize the adoption of best environmental and sustainability practice at all levels of financial institution operations.

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EXECUTIVE SUMMARY

Water is a critical natural capital[1] factor that underpins many industrial processes. Water scarcity is therefore emerging as a potentially material risk for business, particularly for companies that operate in water stressed regions and water intensive industries such as mining.

The most recent Ernst & Young ranking (in 2014) of the top 10 business risks facing the mining and metals industry included – for the first time – "access to water," explaining that the availability of affordable water is "an essential part of operations…and has become increasingly difficult." [2] With competition for water expected to increase and the long lifespan of a typical mine, there is a strong case for systematically factoring water risks into the market valuation of mining companies.

Along with growing recognition of the potential material impacts of water scarcity, the increasing availability of geospatial data makes it feasible to model out possible effects of water risk on revenues and/or costs. The Water Risk Valuation Tool (WRVT) was developed to address the often missing link between corporate environmental risk and financial value. The WRVT is the product of a collaboration between Bloomberg LP and the Natural Capital Declaration (a finance-led initiative managed by the UNEP Finance Initiative and Global Canopy Programme), with support from Bloomberg Philanthropies and the GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit).[3] The WRVT is a practical, high-level demonstration tool that illustrates how water risk can be incorporated into company valuation in the mining sector using familiar financial modelling techniques. The methodology can also be adapted to other relevant sectors and refined to eventually support the creation of plug-and-play tools for market participants.

Development of the WRVT began as an adaptation and expansion of the Carbon Risk Valuation Tool (CRVT) released in 2013 by Bloomberg. This provided a similar, early view into how the concept of "stranded assets" could be translated into a demonstration tool utilizing a standard discounted cash flow (DCF) model by examining valuation impacts on fossil fuel companies under a range of carbon emissions constraints.[4] The CRVT's main asset stranding principle is based on the idea that climate change policies that impose caps on greenhouse gas emissions could induce the stranding of some conventional fossil fuel assets. In contrast, the WRVT models potential asset stranding based on conditions of future physical water scarcity, and estimates the effects of this water risk factor on earnings and share price.

Paired with data from the World Resources Institute's (WRI) Aqueduct database, the WRVT adapts the CRVT's overall approach by mapping specific mine assets against water scarcity indicators projected through 2030. Water risk is then integrated into the model through two primary pathways:

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[1] In the context of this report, natural capital is defined as *'the stock of ecosystems that yields a renewable flow of goods and services'*. Water can be considered a key renewable natural capital good, although resources can become exhausted or depleted.
[2] EY 2014. Business risks facing mining and metals 2014-2015. Ernst & Young.
[3] The water shadow prices used in this tool were provided by the NCD, GIZ and the German Association for Environmental Management in Financial Institutions (VfU). They represent one outcome of a joint project to develop a "Corporate Bonds Water Credit Risk Tool, commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ). These shadow prices are publicly available at naturalcapitaldeclaration.org/bonds-water-scarcity/ and may be used as a basis to develop further tools or methodologies.
[4] Bloomberg, 2013. Bloomberg Carbon Risk Valuation Tool. Bloomberg New Energy Finance: London and New York

(1) on the **revenue side** by calculating the value of potentially unextractable ore due to water scarcity;

(2) on the **cost side** by modeling a so-called “shadow price” of water derived from a Total Economic Value (TEV) framework, which captures a wider variety of factors (i.e., health, ecological) that represent the value of water supplies to other users.

Throughout the model, users are able to utilize overrides to adjust assumptions and pre-set values, thereby enabling a significant amount of customization. For more detailed guidance on use of the tool, please refer to the “Help” tab on the tool itself.

1. PROJECT INTRODUCTION

The Water Risk Valuation Tool (WRVT) is a demonstration project that illustrates how water risk can be incorporated into a standard discounted cash flow (DCF) model to inform the valuation of companies in the mining sector. Developed by project partners Bloomberg LP and the Natural Capital Declaration (NCD), the WRVT is designed to be a conversation starter around the feasibility and efficacy of integrating natural capital considerations—specifically, water risk—into well-established modes of analyzing company value.

The tool is designed for use by a variety of user-types, including financial, mining or Environmental, Social and Governance (ESG) analysts at banks, pension funds etc., to assess the potential materiality of water scarcity on mining equities. The NCD consulted financial institutions on methodological approaches to ensure the practicality of the tool while also integrating science in ways that are compatible with existing investment decision-making systems.[5]

Development of the WRVT began as an expansion of Bloomberg's Carbon Risk Valuation Tool (CRVT), released in 2013, which provided a similar, early view into how the concept of "stranded assets" could be translated into a demonstration tool using a standard DCF model.[6] The WRVT illustrates the potential for natural capital valuation to be integrated into familiar analytic workflows. Its methodological approach is similar to the CRVT, but with a focus on water and, more specifically, the risks posed by water scarcity in the context of mining. It provides a standard approach with the potential to eventually expand and adapt the water risk valuation to other sectors.

The focus on the intersection of water and mining (with a further refined view of gold and copper mining in particular) reflects in part, a pragmatic decision to examine a global phenomenon for which data was readily available[7] and where certain parameters could be chosen to delimit the scope of the tool without compromising feasibility and efficacy.

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[5] Additional NCD projects are in the pipeline that aim to build on the WRVT through research and development, stress testing and new approaches to capture the value—and value at risk—linked to business activities' impacts on natural capital, as well as their dependence on access to biodiversity and ecosystem goods and services.
[6] Bloomberg, 2013. Bloomberg Carbon Risk Valuation Tool. Bloomberg New Energy Finance: London and New York
[7] While not a comprehensive overview of the emergence of water risk as a global phenomenon, a brief scan of headlines contemporaneous to this writing offers motivation enough for the WRVT project: "Squeeze on water hits global food and drink groups," Pilita Clark, *Financial Times*, May 7, 2015; "Brown lawns loom this summer in California as tough water restrictions take hold amid drought," Amy Taxin & Fenit Nirappil, *Associated Press*, May 6, 2015; Sub-Saharan Africa Economy: Water supplies at crucial levels, *Economist Intelligence Unit*, May 6, 2015; and from *Mining Weekly*, "Tomingly suffers from water shortage" (by Esmarie Swanepoel on April 24, 2015).

2. CONTEXT FOR BUILDING THE TOOL

Environmental risks become financially material if they directly or indirectly affect a company's earnings (e.g., EBITDA) or costs. Indeed, water in the context of mining has increasingly significant implications for operating and capital costs along with their associated risks.[8] Competition for water resources between industries such as mining and agriculture is intensifying in some regions. On a global level, current demand for water by agriculture, industry and for domestic use already outstrips supply, and the gap is expected to widen to 40% by 2030.[9]

When comparing external environmental costs as a percentage of EBITDA, mining companies have externalized about 64 cents for every dollar of pre-tax profits through such impacts as greenhouse gas emissions, water use, etc.[10] Externalized environmental costs for the mining industry have risen 133% between 2002 and 2010.[11] Taken together, there may be distortions reflected in company valuation where water risks are not adequately accounted for. The WRVT is meant to help illuminate this gap.

2.1 Mining exposure to water scarcity: growing evidence of potential asset stranding

The costs of water shortages can be stark. They can lead to unanticipated drops in production, as Anglo American experienced when water scarcity in Chile caused production at its Los Bronces mine, the world's sixth-largest copper producer, to fall by as much 30,000 tonnes or 4% of Anglo's overall copper output in 2015.[12] Similarly, water restrictions contributed to a 2% fall in output to 553,000 tonnes at BHP Billiton's Escondida, the world's largest copper mine.[13]

Meanwhile, falling ore grades in Chile, which produces about one-third of the world's copper, are increasing the volume of water needed for production. Despite a sharp increase in seawater use and drought in 2014, freshwater consumption by Chile's copper industry rose 1.9% and the volume of water recycled decreased by 1.3% year-on-year.[14] The Chilean Copper Commission identifies water as a strategic issue and expects salinized and unprocessed seawater use in the country to grow by up to 2.3 times from 2014 levels by 2020.[15]

Mining companies respond to water challenges in a myriad of ways, including some that require significant capital outlays, such as building wastewater recycling systems and large-scale desalination plants in order to secure supplies. For example, BHP Billiton is covering the majority of the $3.43 billion[16] construction cost of a desalination plant at Escondida to secure the mine's water supply from 2017.[17] Freeport-McMoRan is likewise

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[8] GWI, 2014. Water for mining in Latin America. Global Water Intelligence (available at http://www.globalwaterintel.com/market-intelligence-reports/water-mining-latin-america/)
[9] Water Resources Group, 2009. Charting Our Water Future: Economic frameworks to inform decision-making; UNEP, 2011. Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. United Nations Environment Programme
[10] KPMG 2012. Expect the unexpected (available at http://www.kpmg.com/dutchcaribbean/en/Documents/KPMG%20Expect_the_Unexpected_ExctveSmmry_FINAL_WebAccessible.pdf)
11 Ibid.
[12] Drought in Chile curbs copper production, to trim global surplus, Reuters, February 25, 2015
[13] BHP Billiton, Results For Announcement to the Market, February 24, 2015
[14] Global Water Intelligence, Chilean copper mines turn to seawater, but not desal, 24 June 2015
[15] Chilean Copper Commission, Hydrological Consumption in Copper Mining in 2014, February 2015
[16] US Dollars ($) are used throughout this White Paper.
[17] BHP Billiton Operational Review for the Year Ended 30 June 2014, News Release, July 23, 2014

building a $300 million desalination plant for its Minera Candelaria mine.

All told, mining companies globally spent upwards of $12 billion on water infrastructure in 2014 alone, which is an eye-catching 253% increase on the $3.4 billion spent in 2009.[18] Technologies like desalination can also increase operational costs because the process is energy-intensive and water sometimes must be transported over large distances or pumped against steep gradients. As a result, desalinated water can cost up to 10 times more than using locally sourced freshwater.[19]

But the most frequent costs associated with water scarcity are due to lost productivity from delays, and the potentially significant costs of redesigning projects or abandoning them altogether due to social opposition.[20] Access to water can be curbed or denied due to competition for shared resources. For instance, a revision to Chile's water code will eliminate the automatic right held by mining companies to exploit groundwater resources within the limits of their concessions. They will need to obtain government authorization and administrators may refuse permission "if it would compromise the sustainability of the aquifer or the rights of third parties," such as urban populations and farmers.[21]

To be sure, the mining industry is well aware of water risks, and in fact, all twelve U.S.-listed mining companies already report on water-related physical and regulatory risks under the SEC's guidance on climate change risks (which includes water).[22] Although mining companies may include water issues among broad risk disclosures, they may not take account of the extent to which *future* scarcity of water resources can lead to project delays, compromised cash flows and increased capital or operating expenditure in financial statements. Traditionally, a company is valued based on expected future cash flows. In the mining sector, however, up to 40% of a company's value can be based on its mineral reserves and anticipated ability to exploit these. Valuation models do not typically account for the uncertainty in a company's ability to access adequate volumes of water to maintain effective extractive processes.[23]

The WRVT offers a high-level demonstration methodology built on a standard DCF model to illustrate a practical approach to this challenge. It can be later be adapted, developed, and refined to create plug-and-play valuation tools for market participants to more easily integrate water risk into financial analysis.

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[18] A world without water," Pilita Clark, Financial Times, July 14, 2014; GWI, supra.
[19] EY, 2014. Business risks facing mining and metals 2014-2015.
[20] Ryan Dube, "Mining Companies Don't Take Into Account the Cost of Community Conflicts, Study Says," *The Wall Street Journal*, May 12, 2014.
[21] Global Water Intelligence, Chile revokes automatic water rights for miners, 20 August 2015
[22] (U.S. SEC, 2010). The SEC identified a variety of water-related risks that corporations may need to disclose in their financial filings, including "'significant physical effects of climate change, such as effects on the severity of weather (for example, floods and hurricanes), sea level, the arability of farms, and water availability and quality." Ceres, "Clearing the waters: A review of corporate water risk disclosure in SEC filings" (*available at* http://www.ceres.org/resources/reports/clearing-the-waters-a-review-of-corporate-water-risk-disclosure-in-sec-filings)
[23] CDP, 2013. Metals and mining: A sector under water pressure.

3. TOOL METHODOLOGY

This section outlines the technical features of the WRVT by breaking it down into the inputs to the model and the outputs after the model has run its analytics. It then reviews the assumptions and limitations of the model's design and methodology, while highlighting the tool's flexibility to enable users to adjust preset assumptions.

3.1. A familiar framework: discounted cash flow (DCF) analysis

At the heart of the tool is a DCF analysis that incorporates water risk into the overall company valuation. The overall approach to incorporating water risk into future cash flows can be summarized in four basic steps:

1. Assessing water demand at the asset level and calculating the potential supply-demand gap (based on WRI Aqueduct ratios of total annual withdrawals to total available annual renewable supply)
2. Using that supply-demand gap to project how much future production could be inhibited due to lack of water
3. Taking the estimated adjusted production levels on the asset-level and aggregating it to the company level
4. Adjusting the company's future revenue and earnings based on how much production may be impacted by water scarcity

Figure 1 below shows an example of how valuation is impacted by incorporating water risk in this manner.

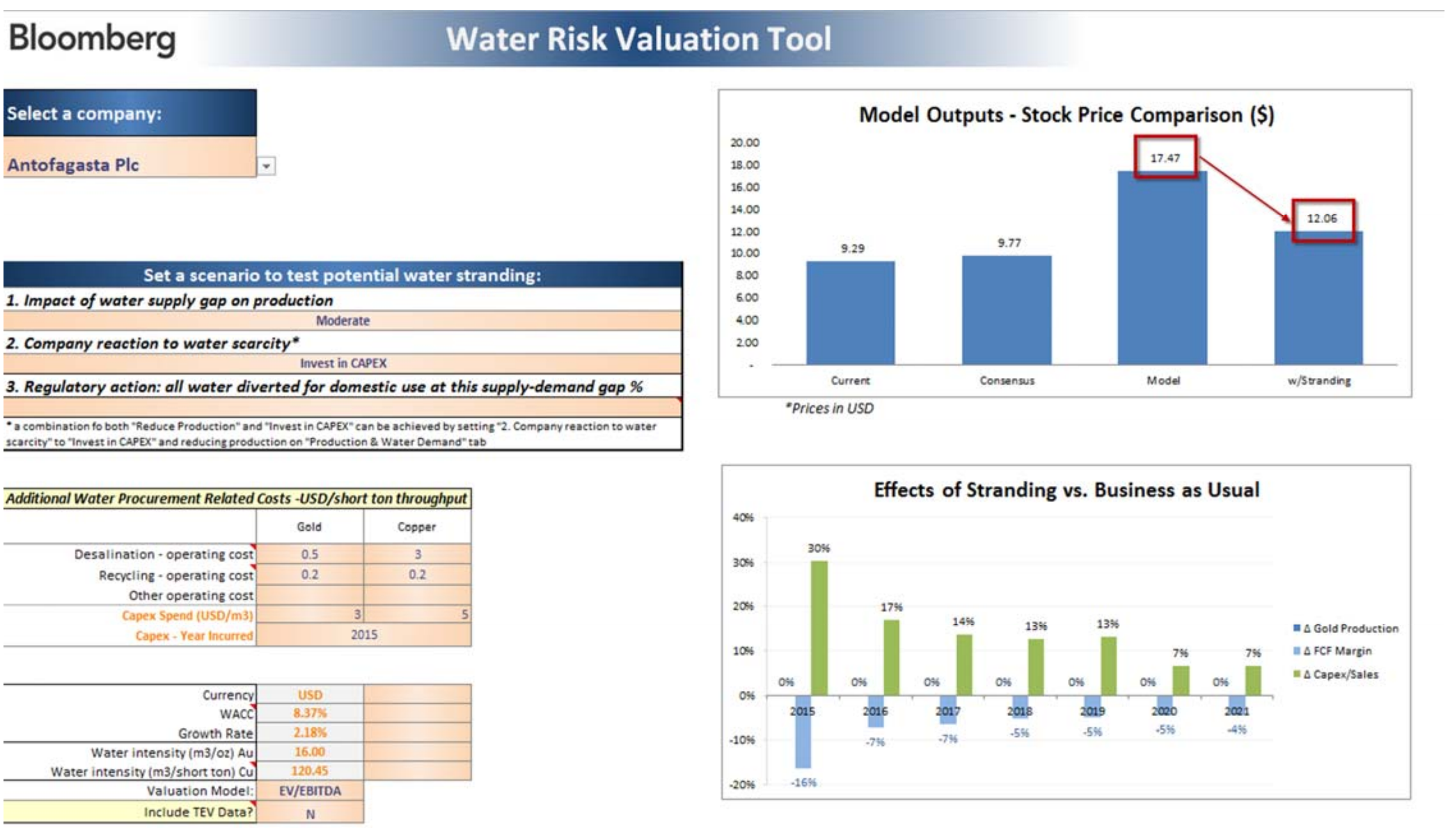

Figure 1. DCF model showing business-as-usual and water stranding scenarios share price outputs

3.2. Water stranding scenarios: the set up

The process of incorporating water risk into the backend data of the valuation model as described above essentially demonstrates how mine reserves can be “stranded” (locked in the ground and not recoverable) due to diminished water supply and competition for resources. Moreover, the stranding scenarios can also be customized to model the triggering of regulatory limits on water allocations to mines.[24]

A more detailed breakdown of the model's mechanics are as follows:

Step one: mapping projections to mine asset locations

The water stranding scenario relies on a mapping of the Bloomberg Intelligence mine asset locations to the World Resources Institutes (WRI) Aqueduct water scarcity projections database[25] for 2030. Projected mine-level water supply-demand data is based on basin-level indicators, where an X% supply-demand gap for the basin reflects a corresponding percentage at risk for the asset. This relationship is by default 1:1, but is user adjustable.

Step two: determining asset-level water demand and future supply shortfall

Based on global average water intensity figures for gold and copper production, the tool estimates water demand at the mine level (“expected production” x “water intensity”) and, using the WRI basin-level scarcity projections data from above, calculates the water supply-demand gap for each mine. Rolling assets up to the company level, the tool calculates how much production is potentially at risk due to water supply gaps. The supply gap is, in turn, fed through the discounted cash flow model to yield estimated impacts on company-level revenue, earnings and share price.

Step three: setting a user-driven stranding scenario in context

The specific parameters driving the scenario can be fine-tuned with the following user-customized inputs:

1. *Impact of water supply gap on production*

Users can refine the relationship between basin-level scarcity and the water scarcity actually experienced at the mine. The default assumes that there is equal impact of scarcity on all users in a given water basin area (1:1 relationship), while other selections allow the relationship to be milder (0.5:1) or more severe (1.5:1). While the tool’s preset scenarios offer these defaults, the field itself is open to be manually set to any ratio desired as users may have additional information.

2. *Company reaction to water scarcity*

The tool captures potential reactions to water scarcity in two primary ways: (1) the company can reduce production based on water supply availability, or (2) it can invest in capex for alternative water solutions. (A combination of both can be set as well.) Furthermore, it is possible to customize alternative solutions by selecting between the desalination, water recycling or “other” options (which is meant to capture alternatives

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[24] *See infra* page 8 (in the main body of the text, section iii discussing the impact of regulatory action and how it is operationalized in the model.

[25] http://www.wri.org/resources/data-sets/aqueduct-water-stress-projections-data

that require capital expenditure but fall outside of the two prevalent options such as graywater recycling) and adjusting the costs for each from global averages.

3. *Regulatory action: all water diverted for domestic use at a threshold supply-demand gap %*

While we have focused on physical scarcity for the majority of the tool, a third option allows for consideration of limits on water rights that may impact water availability due to mandated restrictions to (certain) user groups. For example, legislation may mandate reallocation of water supplies to priority sectors or civil society in times of water crises. In other words, a user can set a certain threshold supply-demand gap at which point any projected future gap beyond that threshold contemplates cutting off *all* water supply to that asset.

4. *The shadow price of water (Total economic value (TEV) framework)*[26]

The tool provides the option to apply so-called “shadow prices” for water used by companies at each mine site. The shadow price determines a cost per cubic meter (m^3) for each location in line with projected ratios of supply and demand for freshwater resources, taking into account a combination of agricultural values, domestic supply values, human health impacts and environmental impacts. The independent variables are water stress and population density, which can indicate potential competition for resources. The resulting costs are aggregated for each company, which reflects an overall “shadow water price” as a leading indicator for exposure to future constraints on the availability of water.

In practice, these shadow costs can be internalized through physical shortages leading to lower production and revenues, increased capex costs for infrastructure, higher opex costs for energy and water treatment, loss of license to operate or restrictions on withdrawals. In the absence of a transparent market price for water use in mining, the company-specific shadow prices provide a proxy for evaluating exposure to water stress (see Appendix B).

3.3. Model results: corporate water risk profile and its valuation consequences

The WRVT provides two final outputs to users: 1) on the “Company-level Water Risk” tab (see Figure 2), summarizes enterprise-level and the individual mine asset water risk exposure (and changes in this exposure by 2021) for each of the 23 publicly listed mining companies covered by the tool. This view allows easy identification of where a company’s main water risks lie currently and in the future.

[26] The TEV model was developed jointly with the joint corporate bonds water risk project of the NCD, GIZ and VfU. See naturalcapitaldeclaration.org/bonds-water-scarcity/

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Eldorado Gold Corp

Total Gold Ouput (M oz) - Latest Reported Year	0.79

		Projected (2020) Water Stress - World Resources Institute					
Overall Water Stress* - World Resources Institute	% Total Production	1.4x decrease	Near Baseline	No data	1.4x increase	2x increase	2.8x or greater increase
Extremely high (>80%)	0%	0%	0%	0%	0%	0%	0%
High (40-80%)	0%	0%	0%	0%	0%	0%	0%
Medium-high (20-40%)	39%	0%	0%	0%	39%	0%	0%
Low-medium (10-20%)	34%	0%	13%	0%	21%	0%	0%
Low (<10%)	11%	0%	11%	0%	0%	0%	0%
Arid and low water use	14%	0%	14%	0%	0%	0%	0%
No data	2%	0%	0%	2%	0%	0%	0%

*baseline year: 2010

Figure 2. Water risk exposure on the company level

2) The second output is the final result from the discounted cash flow model with and without water risk considerations, as shown in Figure 1 on the “Company View” sheet. This part of the tool displays both the user-set stranding scenario options box (which adjusts the main assumptions of the stranding model) and the model results comparing forecasted share prices for DCFs with and without water stranding.

Utilizing financial and operating data on the Bloomberg Professional Service (aka the Bloomberg Terminal), the WRVT provides a straightforward, simplified process for analyzing water risk in the equity valuation context.

3.4. Assumptions and limitations

A full-blown, decision platform that comprehensively accounts for water risk is enormously complex and beyond the scope of the exercise of developing "WRVT 1.0." Therefore, we required a simplifying approach to reduce noise and make the analysis feasible and reasonable given many extant data limitations. But to ensure that there were genuine insights with concrete application, banks and asset managers were consulted on an early-stage version of the tool through workshops in London, New York and Washington, DC, to inform its development. Basic limitations are as follows:

1. The WRVT does not provide projections or forecasts. Rather, it provides a first-cut snapshot to identify which companies and mine sites could be most exposed to water stress.

2. The model assumes that water scarcity will not impact global gold and copper prices. However, in the real world, gold prices could, for instance, eventually respond to production impacts due to water shortfalls. But adequately modelling a recursive relationship between prices and production is a project in itself and can only be reasonably considered in future iterations of the model.

3. There are only four types of forecasting data hardcoded into the model:
   - Broker consensus forecast
   - Production at individual mine sites

- WRI water scarcity projections for 2020 and 2030.
- Shadow water prices (TEVs)

4. Finally, to simplify the exercise, we have relied on linear projections based on historical growth, and thus we have also limited the number of years for which we project earnings and share prices. Similar to our gold price assumptions, these forecasts will need more rigorous modelling in future iterations in order to expand the scope to time horizons more often used by analysts (i.e., closer to a decadal timeframe).

To help address these limitations, the WRVT enables users to reach beyond its boundaries to maximize flexibility through its override fields. An analyst with access to more granular information or a different view on scenarios can fine-tune many of the key inputs to the model by overwriting the model's defaults.

4. APPLICATIONS AND EXAMPLES

This section outlines some case studies to illustrate how analytics and insights from applying the WRVT can be used to assess investment risk and inform corporate engagement. We present four use cases that illustrate in broad strokes how different outputs of the tool can be utilized by analysts.

Case Study 1: Identify macro-level company exposure to water risk

The tool provides a unique macro-level view of water stress exposure (based on WRI data) by aggregating asset-level data on water stress severity and the proportion of total company output located in areas of water stress. This can inform assessments of how resilient a company's overall operations are in the face of current and future water constraints, as demonstrated in Figure 3 below.

For instance, the tool shows that 80% of Capstone's copper production is located at the water-stressed Pinto Valley mine in the United States and Cozamin mine in Mexico. By 2020:

- 61% of the company's production may experience an **increase in water stress** by 1.4 times baseline
- 37% of total production output will hold steady at 2010 levels of water stress

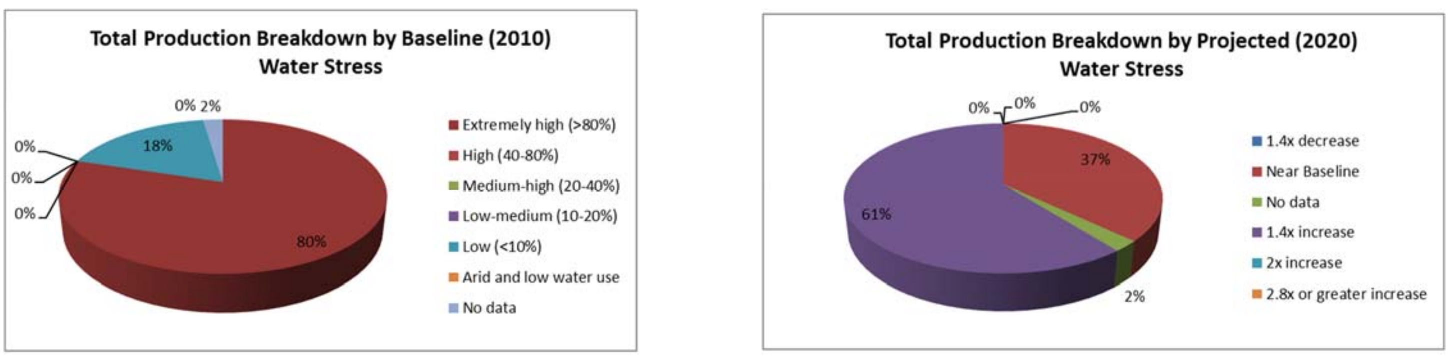
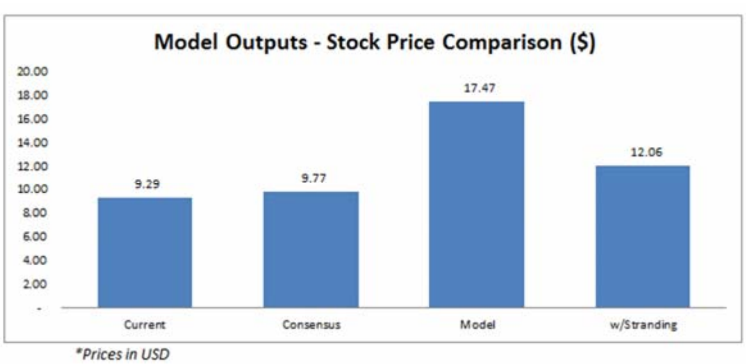


Figure 3. Capstone: Change in % of production exposure to water stress between 2010 and 2020

Case Study 2: Model potential unanticipated cash flow fluctuations

A mining analyst could use the WRVT to model potential unanticipated cash flow fluctuations from potential production loss and/or increased costs to maintain production under conditions of water stress.



DCF Valuation Model	With Stranding	No Stranding
Terminal Year FCF	1,735	2262
NPV of Free Cash Flow	3,817	6,352
+ Terminal FCF Value	15,959	20,813
Enterprise Value	19,776	27,166
+ Cash and Near Cash	845	845
- Total Debt	2,376	2,376
- Minority Interest	1,861	1,861
Total Equity Value	16,384	23,774
Shares Outstanding (# Mill	986	986
Theoretical Value per Shar	16.62	24.11

in USD Million, unless otherwise indicated

Figure 4. The WRVT enables users to easily model and observe the impacts of water stress on mining equity valuations

For instance, using the default settings on the WRVT demonstrates that a water supply gap could theoretically have an impact on Antofagasta (Figure 4):

- The model shows a 40% difference in **free cash flow** between the DCF outputs that incorporate and exclude water risk considerations (model estimate of $3,817 million (considering water risk) vs. $6,352 million (business as usual) in 2021).
- This in turn would impact Antofagasta's **total equity value** and result in a lower projected share price. It is important to note that these figures are not to be interpreted in absolute terms as price targets, but rather a demonstration exercise to **observe the relative differences** between model results for business as usual ("Model" in Figure 4) and water risk considered ("w/Stranding" in Figure 4).

Case Study 3: Pricing risk using a customizable framework and shadow prices

For the investor already factoring in ESG issues, the tool can complement existing assessments of water use by mining/extractives companies. The tool could be a potentially useful identifier of companies in a portfolio with the most or least water risk and help pinpoint underlying factors to more accurately price water risk. For example, the analyst can, in partnership with the client and the credit team, customize the dynamic framework to price risk and account for mitigation efforts:

- Combine **shadow prices** with water use, production and reserves data, to identify stress points and evaluate potential limits to expanding ore extraction at specific mines
- Use data provided by the company itself to **override estimated information** or assumptions in the model to take into account *actual* water-related expenditure and risk management
- **Incorporate forecasted expenditure** on water rights, water supplies, and water treatment and recovery activities to adjust potential future capex and opex costs. This can provide a more refined, quantitative overview of the risk, which, if significant, can also inform credit conditions.

For instance, integrating shadow water prices for 2020 into the model (see Figure 5) results in a potential 10% or higher fall in the share prices of several companies analyzed. The WRVT results can be used to guide further qualitative research into how these risks might play out for the companies and sites that are most exposed, by evaluating management responses and policy environments at production sites most exposed to water stress. If an asset manager believes water governance and infrastructure will address water scarcity at a specific location for the lifetime of the mine, the analyst may lower estimates of production losses modelled in the WRVT.

Revenue with Stranding		9,086	8,658	8,640	9,629	9,541	9,539	9,570
Depreciation & Amortization		1,788	1,780	1,444	723	723	723	723
	Depreciation & Amortization (% of Capex)	*95.8%*	*103.2%*	*78.4%*	*-35.6%*	*48.7%*	*30.5%*	*14.5%*
	User Defined Dep. & Amort. (% of Capex)							
Depreciation & Amortization w/o Stranding		1,836	1,829	1,483	742	742	742	742
	Depreciation & Amortization (% of Capex)	*95.8%*	*103.2%*	*78.4%*	*-35.6%*	*48.7%*	*30.5%*	*14.5%*
	User Defined Dep. & Amort. (% of Capex)							
Additional Water Procurement Operating Cost		46.5	44.6	44.5	45.2	44.8	44.8	44.9
TEV costs		100.8	116.1	133.2	156.1	173.7	192.8	213.0

Figure 5. TEV costs for a company from 2010-2021

Case Study 4: Active ownership practices — ESG commitments, engagement and proxy voting
The WRVT can help investors meet commitments to integrate ESG factors into investment analysis and decision-making, and report on progress to the UN-supported Principles for Responsible Investment (PRI). Asset owners could request that internal or external asset managers:

1. For actively managed portfolios of listed equities, use a tool such as the WRVT to assess the variations in exposure to water scarcity across the assets of mining companies with implications for the share price of individual listed mining companies or the aggregated effect on an index. This information could be relevant during considerations to underweight or overweight a particular stock, or tilt an index based on material ESG risks.

2. Use tools like the WRVT for active ownership practices including engagement and proxy voting. This can be done individually or collaboratively (e.g., through the Clearing House of the PRI). The outputs of the WRVT can inform engagement with companies by providing an evidence base upon which to encourage discussion of the company's water management and risk mitigation.

The tool can be used to engage companies on water use as a fundamental risk management issue. For example, using a standard enterprise value/earnings model, the WRVT shows a potential 18% fall in total equity value for Barrick Gold Corp due to exposure to water stress (Figure 6). In the specific context of mitigating risks in mining, the WRVT can be used to explore whether capital expenditure for new mines in regions with existing or expected water stress is viable.

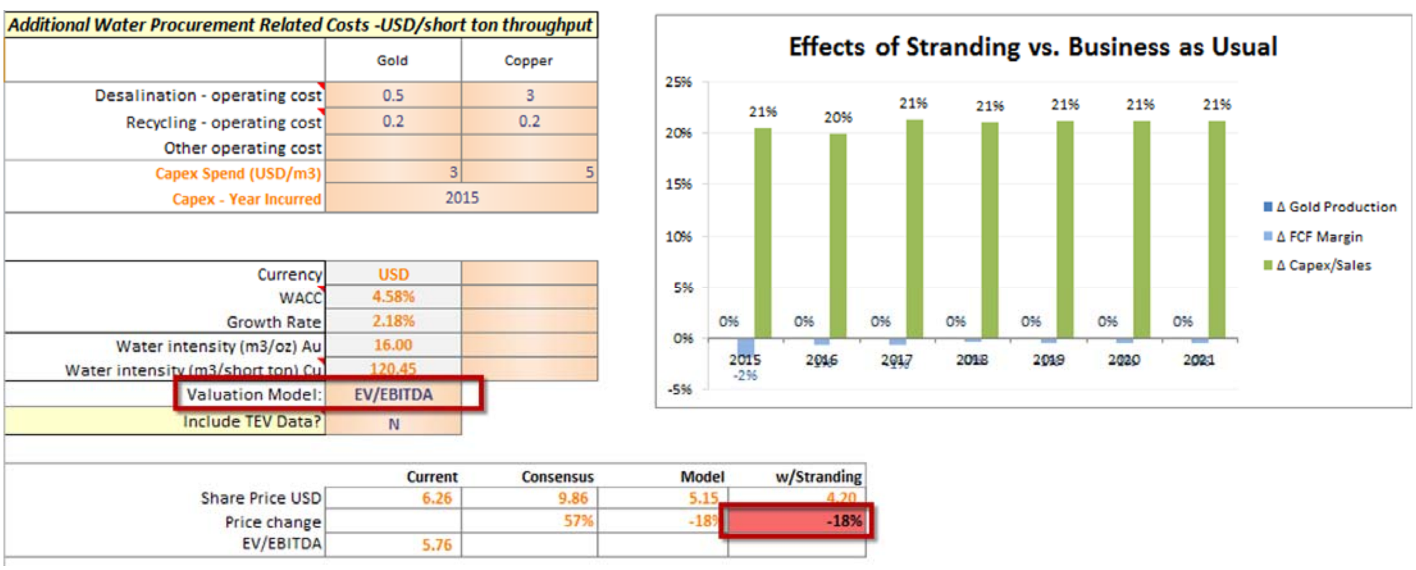


Figure 6. Water-related capex can be modelled and included in EV/EBITDA models

5. LOOKING AHEAD

WRVT 1.0 should be regarded as a conversation starter around risks (and potential relative opportunities) associated with water scarcity. Enhanced financial analytics to systematically assess exposure of holdings in water-intensive sectors such as mining are needed if portfolios are to have stable returns in areas under increasing water stress. Indeed, natural capital implications extend well beyond water and mining, which presents a clear challenge to the extent that the development of applicable tools and methodologies is at best nascent. In future iterations, we look to apply this tool to other sectors where water is a material risk; ultimately, this represents a significant opportunity for advancement on the part of investors, analysts, and companies alike.

While WRVT 1.0 gets us part of the way, there is much more one can imagine for the development of a WRVT 2.0. While we do not preview any specific plans here, we do note that a portfolio view, more specific and grounded assumptions around production drop offs per unit of water loss, dealing with the endogeneity of gold or copper prices and their relationship to production levels, or even the overlay of other considerations beyond water (say a more sophisticated operationalization of regulatory risk) would all be potential exploratory directions for a 2.0 version. Feedback is welcome to help inform potential future iterations and applications of the tool.

And, as ever, these tools and methodologies are only as useful as relevant data is available in a high-quality, complete, and comparable format. As discussed, the WRVT's design reflects practical decisions based in part on the availability of asset-level data. To the extent that data is the lifeblood of quality analysis, we support those mechanisms that generate transparency, quality data, and thereby enable the development of analytic tools with greater efficacy. We call on reporting standard-setters to request more granular, site-level quantitative disclosures on water use by companies in sectors such as mining, food & beverages, and utilities.

APPENDIX A: WATER TOOL LANDSCAPE

This section summarizes some of the key features of existing open-source water tools for businesses and investors

WRI Aqueduct Tool

The Aqueduct tool features a publicly available global database and an interactive mapping tool to provide information on water risk, including projected change indicators. Three categories of water risk are incorporated: Physical risk – quantity; Physical risk – quality; and Regulatory & Reputational risk, for a total of 12 indicators that are aggregated into overall scores. The data comes from over 30 data sources, including Intergovernmental Panel on Climate Change data on projected changes in water availability worldwide in 2020, 2030 and 2040. Both withdrawals and consumptive use are considered at the hydrological catchment scale. The tool is aimed at helping companies and investors understand water-related risk to business, and for use by other stakeholders to understand water issues.

World Business Council for Sustainable Development (WBCSD) Global Water Tool (GWT)

The GWT is a free, publicly available resource for identifying corporate water risks and opportunities aimed at companies. It includes a workbook (data input, inventory by site, key reporting indicators, metrics calculations), a mapping function to plot sites with datasets, and a Google Earth interface for spatial viewing. Companies can use the tool to compare sites with the best available water, sanitation, population and biodiversity information on a country and watershed basis to explore levels of current and future risk exposure in water-scarce areas.

WWF-DEG Water Risk Filter

This tool is aimed at companies to assess water related risks for operations, suppliers or growth plans. Investors or creditors can use the risk assessment to help identify potentially significant risks for clients and therefore returns on investment. The tool is based on responses to a questionnaire covering water-related issues including water quantity and quality, and covers risks including reputational and regulatory risk. Water risk scores range from 1-5, from no risk/very limited risk to high risk.

CERES Aqua Gauge

The Aqua Gauge was developed by Ceres, the World Business Council for Sustainable Development, Irbaris and the IRRC Institute in consultation with over 50 investors, companies and NGOs. It is an Excel-based assessment tool to evaluate an existing water strategy or to build one from the ground up. The Aqua Gauge helps companies to: Frame and assess options for managing water risk; define an effective water risk management approach and benchmark current activities against leading practices; prioritize and improve responses to water risk; and communicate key water risk information to stakeholders including investors. The Aqua Gauge also provides guidance on how to respond to water-related physical, reputational and regulatory risks.

GEMI Local Water Tool

Global Environmental Management Initiative (GEMI) has developed the Water Sustainability Tool to help companies and other organizations better understand what emerging water issues might mean for their operations in order to build a business water strategy. The tool encourages businesses to identify water-related risks and opportunities; assess the business case for action; develop a water strategy; and ensure that water-related opportunities and risks are tracked and managed effectively.

Trucost/Ecolab Water Risk Monetizer

Companies can use the Water Risk Monetizer to assess the potential impact of water scarcity on costs and production. It provides a monetary estimate of the full value of water at the facility level, based on what water would cost if supply and demand were accurately priced; and estimates potential revenue at risk due to the impact of water scarcity on operations.

Veolia - True Cost of Water Tool
Veolia Water Technologies has developed a tool to estimate the "true cost of water" to help companies make business cases and ROI decisions for water investment. It goes beyond the price of water and incorporates direct, indirect and adjusted monetized risks. The Excel spreadsheet includes the option to estimate the costs of mitigating water risk. These costs are categorized as operational, financial (ex. cost of capital), regulatory (meeting ecological standards) and reputational (license to operate).

GIZ/NCD/VfU Corporate Bonds Water Risk (CBWR) Tool

The NCD, the German International Cooperation (GIZ) and the German Association for Environmental Management in Financial Institutions (VfU), together with seven financial institutions from Europe, Latin America and the U.S., developed a methodology and tool to integrate exposure to water stress in corporate bond credit analysis in the beverages, power and mining sectors. The project, commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ), developed the water valuations (TEV) also used in the WRVT and is accessible at naturalcapitaldeclaration.org/bonds-water-scarcity/

Common elements between the WRVT and CBWR tools are the use of the WRI Aqueduct Water Risk Atlas data on water quantity, including project changes in water supply, water demand, water stress, etc. Additional common elements concern the use of shadow prices as a proxy to estimate potential future water costs and evaluating company-level water risk to benchmark company results against peers.

APPENDIX B: TEV METHODOLOGY

The tool provides the option to apply shadow prices to quantities of water used by companies at each mine site. This cost per cubic meter (m^3) varies for each location in line with projected ratios of supply and demand for freshwater resources. The resulting costs are aggregated for each company to create an overall "shadow water cost" as a leading indicator for exposure to future constraints on access to resources. This can be due to a combination of expected changes in demand and supply.

Data on actual water costs paid by companies is limited and current water tariffs do not indicate exposure to future water-related costs due to increased competition for resources or changes in availability. At best, tariffs provide a lagging indicator for historical supply-demand gaps, as utilities attempt to recover infrastructure, operating and maintenance costs. At any rate, mining companies frequently withdraw water directly from surface and groundwater sources as well as, or instead of, purchasing supplies from utilities.

Shadow costs provide a forward looking indicator to take account of exposure to potential changes in the cost or availability of water as a key input for production. A quantitative valuation of water is one approach to flexibly include water risk in traditional financial analysis for sensitivity analysis. Shadow prices can be used to identify which sites and companies could be most at risk from water stress. The indicator can help target further due diligence to evaluate factors such as regulatory and governance frameworks and preparedness for changing operating conditions, focusing on assets most exposed to water-related risk.

Companies including Nestlé use shadow prices to inform decision-making by considering shadow water costs in decisions to invest in equipment, similar to the use of shadow carbon prices to adjust calculations for returns on investments in low-carbon infrastructure. However, the internalization of shadow costs for water is less dependent on policy intervention, since lack of regulation can exacerbate overuse of shared water resources, and the effects are more localized. The effects on company operations are also likely to be more sudden than carbon pricing. For example, in drought-stricken parts of Brazil and the U.S. state of California, rationing was introduced more rapidly than companies could invest capex to conserve, manage or obtain secure water supplies.

Approach and methodology

The Natural Capital Declaration (NCD) worked in partnership with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the German Association for Environmental Management and Sustainability in Financial Institutions (VfU) on a project commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ), to develop a methodology to estimate shadow water prices to reflect the scarcity of resources worldwide.[27]

An environmental economics approach used in the public sector, known as the "total economic value" or TEV framework, was used to estimate the value of water as an indicator for water scarcity. The shadow price for each marginal unit used, in the context of available resources at each geographic location, provides a proxy for water risk as competition for resources. The TEV attempts to capture the full economic value of water, including the external benefits that water provides to society and the environment, in addition to the private benefit gained by water consumers.

Water is valued at a specific location by considering its alternative uses. It is assumed that 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.

[27] The water shadow prices used in this tool were derived by the NCD, GIZ and VfU, in partnership with David Boland, an Ecological Economist and Founder of DBRM Associates, and supported by an Expert Council established for the joint project. Bloomberg is represented in the Expert Council. These shadow prices are publicly available at naturalcapitaldeclaration.org/bonds-water-scarcity

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