Water risks and financial market

Overview and analysis

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Acronyms and abbreviations

2030	WRG 2030 Water Resources Group
AGWA	Alliance for Global Water Adaptation
BAU	Business As Usual
BMAP	Bloomberg Map
BMZ	German Federal Ministry for Economic Cooperation and Development
CAPEX	Capital expenditures (is not yet fully written-out in the text, only as “investments”)
CDP	Carbon Disclosure Project (is not yet fully written-out in the text)
COP	Conference of Parties
DJSI	Dow Jones Sustainability Index
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortization
EMSD	Emerging Market Sustainability Dialogues
FAO	Food and Agriculture Organization of the United Nations (is not yet fully written-out in the text)
FOEN	Swiss Federal Office for the Environment
GEMI	Global Environmental Management Initiative
GHG	Greenhouse gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GRI	Global Reporting Initiative
GWT	Global Water Tool
IEA	International Energy Agency (is not yet fully written-out in the text)
IHA	International Hydropower Association (is not yet fully written-out in the text)
IPCC	Intergovernmental Panel on Climate Change
IRRC	Investor Responsibility Research Center
IUCN	International Union for Conservation of Nature (is not yet fully written-out in the text)

LWT	Local Water Tool (Abbreviation is not added at first instance, only the full name)
m^3	Cubic Meter(s)
NCD	Natural Capital Declaration
NCFA	Natural Capital Finance Alliance
NDC	Nationally determined contributions (is not yet fully written-out in the text)
OPEX	Operational costs
RMS	Risk Management Solutions
SASB	Sustainability Accounting Standards Board
SDGs	Sustainable Development Goals
SIWI	Stockholm International Water Institute (is not yet fully written-out in the text)
TCFD	Task Force on Climate-related Financial Disclosure
TEV	Total Economic Value
TNC	The Nature Conservancy
UNECE	United Nations Economic Commission for Europe
UNEP FI	United Nations Environment - Finance Initiative
UNFCCC	United Nations Framework Convention on Climate Change
UNW-DPAC	United Nations - Water Decade Programme on Advocacy and Communication
USD	US dollar
VfU	German Association for Environmental Management and Sustainability in Financial Institutions
WASH	Access to Safe Water, Sanitation and Hygiene
WBCSD	World Business Council For Sustainable Development
WEF	World Economic Forum
WFN	Westbank First Nation
WRF	WWF Water Risk Filter
WRG	2030 Water Resources Group
WRI	World Resource Institute
WRM	Water Resources Management
WRVT	Water Risk Valuation Tool
WWF	World Wildlife Fund

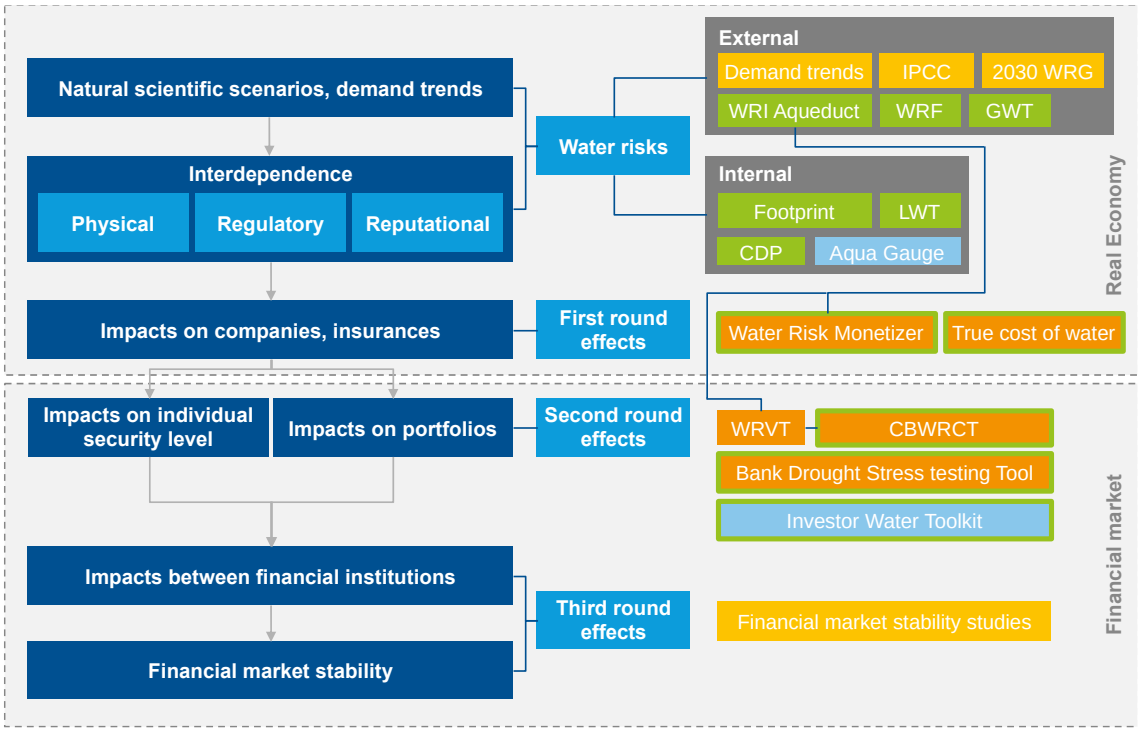
Executive summary

This study explores the importance of water risks for the overall economy and the financial system and reviews the availability of data, models, tools and studies to assess the impacts of water risks on the real economy and the financial market (both institutional and systemic level is explored). In addition to the risk perspective, this study also explores, if there are alignment strategies, thus investment strategies aiming at contributing to international water goals or scientific findings on adequate use of water (quantity and quality).

Water risks are not only felt in the real economy but also lead to implications in the financial system due to decreased revenues and increased costs within invested companies, and interdependency of affected financial institutions. We can distinguish between *physical, regulatory and reputational water risks*. These can have ripple down effects to individual securities and portfolios across all asset classes. However, the challenge is to understand materiality and timing of water impacts on specific asset classes, sectors and industries. In comparison with climate change, water conditions can strongly vary over time and location.

Climate change is strongly intertwined with water risk management and so are hydrological water cycles and biodiversity, which asks for a more holistic approach of managing water risks from a public-sector perspective. According to the recommendations of the Task Force on Climate-related Financial Disclosure (TCFD), companies and investors alike should consider water-scenario analyses in their long-term strategy, growth and cost considerations. However, holistic scenarios and related water-risk associated mitigation paths are currently inexistent. Several multilateral environmental agreements have water at their core and water is highly ranked within the 2030 Agenda for Sustainable Development with a dedicated Sustainable Development Goal 6 ("Ensure availability and sustainable management of water and sanitation for all"). Therefore, water is connected across sectors, other natural resources and international agreements.

Figure: Direct and indirect effects of water risks and available tools (Source: South Pole)



The study gives an overview and qualitatively evaluates 13 different databases, scenarios, models and tools to display water risks in the real economy and financial products, portfolios, financial institutions, and even the financial system. The amount as well as the variety of data and

tools on water risks for actors both in the real economy as well as in the financial market is ever-growing. Since investors have only recently started to assess water risks, more water risk assessment tools have been established for the real economy rather than for the financial market.

Notwithstanding the growing number of available tools and their continuous development, the assessed tools show several shortcomings from a public policy perspective. They, for example, mainly cover physical risks, notably baseline water stress, while the equally important reputational and regulatory risks are neglected. Additionally, the quantified higher operating costs through shadow prices are mostly material over the long term, while both real economy and financial sectors are more interested in short term effects like a company losing access to key markets or locations either due to flooding, water scarcity or opposition from local communities. Therefore, the current tools and data are not necessarily suited to engage the private sector for alignment with public water policy goals.

We have not found any existing investment strategies that align investments with internationally agreed water-related goals or scientific findings on adequate use of water. In practice, several investment strategies or vehicles dealing with water risks have been developed but the focus is almost exclusively on water risk management and opportunity exploration from a pure business perspective and the strategies do not pursue alignment. Therefore, no clear alignment strategies to global policy goals or a scientifically proven consensus could be identified. It seems that this lack of alignment is not just related to preferences within the financial industry but also the general lack of well-known and internationally recognised policy goals or science-based targets on water. The closest to a benchmark for alignment are general recommendations within financial industry associations on how to deal with water risks. A potential future alignment approach could be to extend the basin-level concept of Water Stewardship from corporates to investors.

1 Background and goal

The exceedance of our planet's carrying capacity, due to the lack of action to protect and sustainably use water and biodiversity, poses a great threat to our economy and society. If our economy is continuing to run as usual, high costs to limit damages will arise and can, therefore, create a lack of funds to invest in a transition to a resilient and resource-efficient economy. The financial sector plays a crucial role to accelerate this transition due to its steering function. A systematic integration of environmental risks and opportunities through financial players could lead to direct financial flows to this transition and at the same time investments in non-sustainable technologies are avoided.

The FOEN supports and promotes the transition into a resource efficient economy nationally and internationally. This includes integrated water resources management. The financial sector plays a vital role in financing the transition and avoiding stranded, drying or drowning assets. Therefore, the FOEN wants to assess the feasibility of measuring the Swiss financial market's exposure to water alignment / sustainable water use. Especially, to understand the availability of different approaches for water compatible investment strategies, how this potentially interferes with some investors approaches to manage water risk and to gather evidence on how this could lead to 'water aligned' portfolios.

Water risk in the context of this study are understood as water-related risks for individual financial players, corporates and individuals that lead to risks for the whole economy and the financial system. Alignment is understood as the alignment of water management strategies of investors and companies with public policy goals or scientifically developed targets. The following two key dimensions and its accompanying questions are addressed in this study:

1. **Water risks and their importance for the real economy and the financial market:**
    - What is the process / link between the impact of water risks (and opportunities) on the economy and subsequently on the financial market?
    - How significantly can water risks influence the stability of the financial market?
    - What are the characteristics of the mostly local water risks compared to other more global environmental risks?
    - To what extent can synergies between climate and water be leveraged, e.g. with regards to instruments and data?
2. **Availability of data, models, tools and studies to assess the impacts of water risks on the real economy and the financial market:**
    - What is the accessibility and qualitative reliability of data and information regarding water risks for the real economy?
    - Which methods and models exist that include local water risks / opportunities into investment decisions and to quantify its impact on transactions, asset classes, financial products or even the financial market?
    - Which insights regarding alignment approaches and water compatible investment strategies already exist and which ones would need to be further investigated and developed?

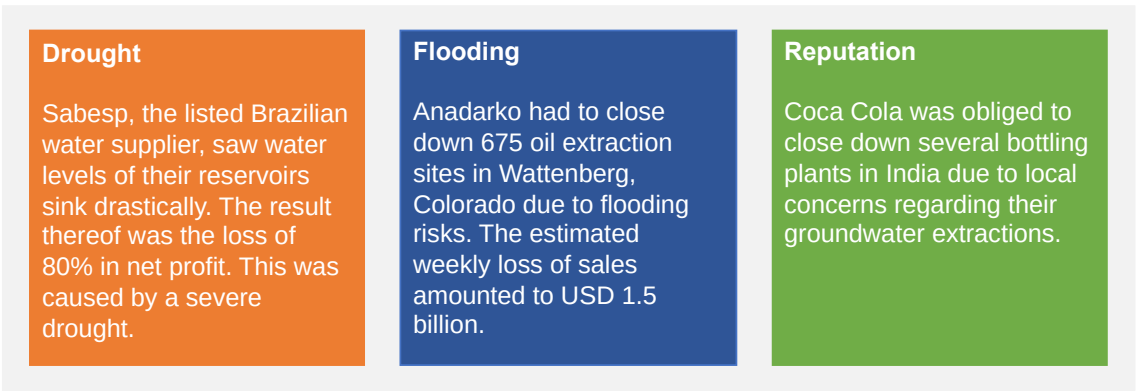
2 Overview of water risks and opportunities, its context and implications for the financial market

The following chapter gives an overview of the connection between water risks as well as opportunities and the financial market. For this purpose, different aspects of water risks and their relevance for the real economy and the financial market, synergies and differences between natural resources and global conventions and scenarios are considered and highlighted.

2.1 The importance of water risks for the real economy

Water is a universal solvent and coolant and vital for all life on earth. Freshwater is a finite resource and only accounts for a share of 2.5 percent of the global water reserves. Furthermore, its occurrence and reserves vary over time and across geographies. Its importance to the real economy has moved to the top of the agenda of the World Economic Forum (WEF), and water crises have consistently featured among the top-ranked global risks facing the planet over the next 10 years. Already today, the materialized effects of water risks along the value chain of companies are tangible. According to 500 listed companies, the incurred costs of business impacts due to water risks amounted to USD 14 billion within 2015 alone (CDP, 2016, S. 14). According to these companies, the biggest drivers of water risks are water scarcity (including water stress) and flooding events as well as climate change, which is exacerbating both mentioned drivers. These risks lead to higher production costs, interruptions in the supply of raw materials, loss of production volume and reputational issues (CDP, 2017, S. 9). These implications on operations or supply chain can impair income statements, balance sheets and growth strategies (Ceres, 2015, 33; China Water Risk, 2016), see Figure 1. Therefore, water risks can lead to material financial implications that manifest in decreased revenues, increased costs or limited access to equity and debt.

Figure 1: Concrete examples of financial losses due to water risks



2.2 The importance of water risks for the financial sector

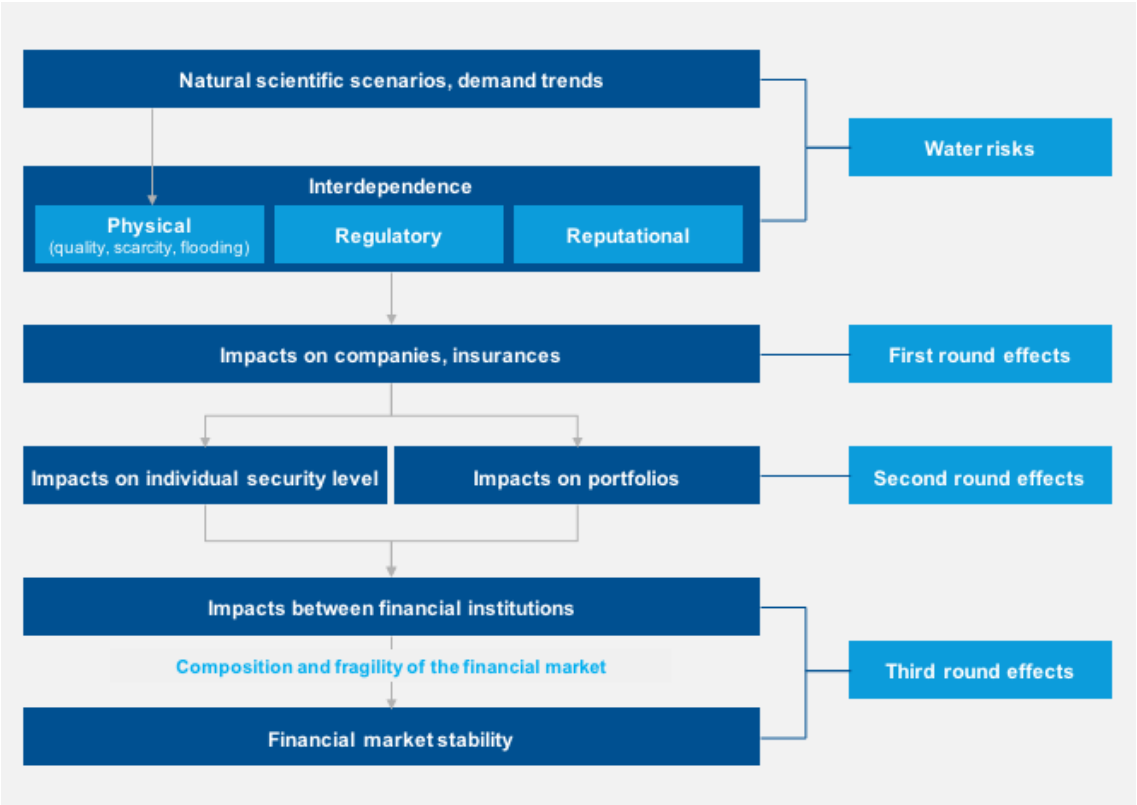
Water risks are not only eminent for the real economy but are also felt on the financial market in a secondary role. According to studies (such as Ceres, 2015, S. 13, China Water Risk, 2016, Water Investor Toolkit, 2017) investors across all asset classes are also exposed to physical, regulatory and reputational water risks. The challenge is to understand materiality and timing of water impacts on specific asset classes, sectors and industries. Revenue and growth are most impacted by water risks, and material to investors especially in the short term, mainly due to extreme weather events or social opposition. Impacts on operating costs, such as raising water tariffs are of less immediate concern, but can impact companies' performance over the longer term. In addition, climate change and growing water demand exacerbate water issues in the long term. Water risks are location-dependent whereas companies and investors often operate on a multinational level. Therefore, they are partially able to adapt their production in a flexible manner. Different water uses across various business areas of a single company pose an additional

challenge to relate these to the gross trading profit. The effects relevant for investors are, therefore, rather difficult to quantify. The launch of the Investor Water Toolkit by Ceres in December 2017 is a first attempt to provide investors with a methodological approach and provide relevant links to useful data and tools; though it is mainly a tool to manage water risk for investors and does not promote alignment with policy goals as such.

Affected investors not only include shareholders of a company with large water dependencies, but also owners of physical assets such as agricultural land, real estate or commodities as well as owners of positions within debt instruments of the public or private sector. The number one concern of investors with all sorts of assets in the mining and energy industry in China is regulatory water risk. Water scarcity was judged to be more urgent than flooding or water-related reputational risks, as these can be covered more easily through insurances or better management (China Water Risk, 2016, S. 34). Key water risks during the due diligence for real asset class managers include access to sufficient quantity and quality, along with regulatory issues around water, especially in agriculture, real estate, infrastructure and forests. With regards to managing water risks, investors choose to diversify. However, sooner or later, this requires a clear analysis of regional geographic risk exposure. Water risk assessments are crucial both at the buy decision as well as through the life of the investment (Brown, 2016).

The effects of water risks affect the financial market in a direct and indirect manner as is shown in 2. Water risks and opportunities can affect the financial market directly by changing the value of individual companies or projects of the real economy as well as insurance claims (first round effects). Indirectly water risks can affect the financial players through devaluations at the individual asset as well as at the portfolio level throughout all asset classes (second round effects). Lastly, through investments in affected financial players, where the financial market as a whole is concerned (third round effects). Further explanation follows below and in Chapter 3.1.1 in the overview and approach of assessing available tools.

Figure 2: Water risks and their direct and indirect effects on the financial market (Source: Own figure - based on Stadelmann et al., 2016)



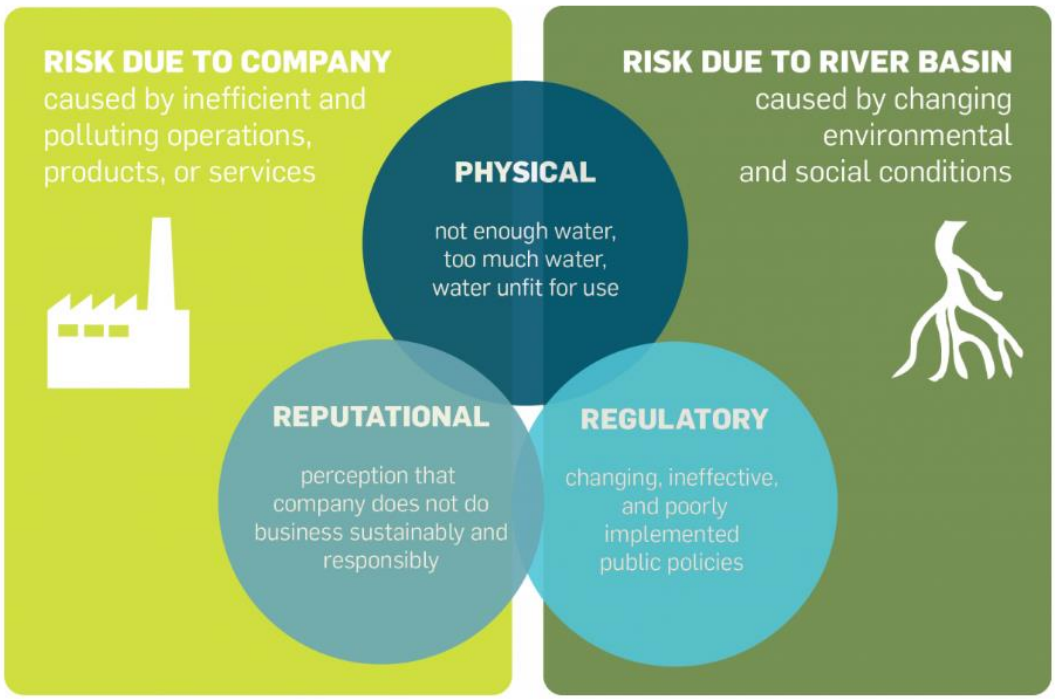
Assessing water risk exposure of the real economy (first round effects) – core concepts

Water risk in the context of this study is considered from a macroeconomic perspective. In line with advanced water risk assessments, this study distinguishes between *physical, regulatory and reputational risks* which is also highlighted in 3. The most obvious challenges, that all businesses face, are related to physical water risks, meaning the lack or overabundance of water and water that is of unfit quality. Water-related risks can also be caused by how water resources are publicly managed and how water use rights are distributed, so-called regulatory risks. The public sector can use regulatory measures to send the right signals in order for the private sector to align itself to said water risks. Furthermore, the perception of key stakeholders - communities, customers and NGOs - regarding a company's impact on water and can lead to reputational risks. In addition to these direct risks many sectors face indirect water risks through increased energy prices or increasing costs for water purification prior to usage.

Companies' water risks are shaped by two type of risk factors; external and internal (Orr and Pegram, 2014, WRF).

- *External risk factors* ('risk due to a river/groundwater basin' in Figure 3) are based on events and developments outside of the factory, but within the basin. Examples of external water risk factors include widespread drought or increasing consumption or pollution of water resources of actors located upstream in the basin. External factors also refer to long term trends. These include population growth, economic development, expected demand changes within electricity or agriculture industries (projected by the IEA, IHA or FAO), climatic changes (IPCC 5th report) or future water gaps (2030 WRG).
- *Internal risk factors* ('risk due to company' in Figure 3) consider how a company is dealing with water resources internally, including the management of external factors. Internal factors e.g. consider management practices that may mitigate external risks, such as access to alternative water sources or collaboration with other stakeholders.

Figure 3: The various types of water related business risks (CEO Water Mandate, 2018)



2.3 Synergies with and differences to other natural resources

The land, water and energy nexus needs integrated approaches in risk measurement and management (UNEP, 2017, p. 14; China Water Risk, 2016). According to the World Resource Institute (WRI) and IUCN there is a strong relation between natural infrastructure, such as forests or stripes of vegetation along the course of a river, and risks due to water. For example, through biological absorption processes a contamination through runoff of pesticides can be prevented and these areas are at the same time home to a manifold flora and fauna. With local water funds, such as the ones launched by The Nature Conservancy (TNC), even financial instruments have been created emphasising the topical importance as well as the appetite of corporate investors for such cross-resource interventions. These kinds of financial instruments mainly focus on basins in Latin America, where for example Coca Cola and SAB Miller invest in upstream wetlands to increase the water quality of their breweries or bottling plants. Furthermore, with the "Global Forest Watch Water" by WRI Aqueduct a visualisation of water risks of 230 basins is possible, enabling the identification of the subsequent potential for increasing tree cover.

According to the UN, water is the primary medium through which climate change is felt. The fifth IPCC Assessment report (IPCC, 2014) models the impact of climate change on the global water cycle from a water supply perspective. It confirms that the frequency as well as the intensity of floods (in Asia, tropical Africa and South America) and droughts are increasing by the end of the century. Many Nationally Determined Contributions (NDC) under the Paris Agreement stress the role of water in mitigation through Greenhouse Gas (GHG) reductions from energy use and wastewater handling. Therefore, the more mitigation of GHG emissions, the likelier the 2-degree goal can be achieved, the smaller the water risks. With regards to adaptation, in the NDCs, water is the most prioritised adaptation sector. Improved water risk management is closely linked to climate change adaptation. On a company level, connections between greenhouse gases and water are the most often reported linkages, e.g. due to energy- or emission-intensive water pumps or thermal desalination plants. There is usually a positive correlation between investments in renewable energy and reduced water impacts (with the exception of large hydro and concentrated solar power plants[1] that have a great water demand). Examples include the reduced risk of changes in water temperature compared to the cooling of thermal power plants (Ceres, 2015, p. 26; CDP Global Water Report 2016/17).

In conclusion, water and its associated risks are mostly local problems, which can also be impacted by regional transboundary water management, whereas climate change is a global environmental issue. This difference has a strong implication on financial water risk; while climate change as global problem may (at least in theory) lead to global financial market shocks (e.g. sudden change in regulation), water as a local risk is more likely to affect individual investors or certain portfolios that are exposed to geographical water risks, but not the global financial market as a whole. Depending on the scope or background of an assessment of the water risks exposure of financial market, an isolated water perspective might be more expedient than an integrated consideration including climate and biodiversity.

2.4 Scenarios and targets of international water policy

According to the recommendations of the Task Force on Climate-related Financial Disclosure (TCFD) companies and investors alike should consider scenario analyses, including potential water scenario analyses, in their long-term strategy, growth and cost development. While sensitivity analyses examine the impact of incremental/gradual changes of a few risk factors, for example the effect of an increase of water prices on operating costs, scenario analyses consider

[1] Concentrated solar power systems are a great promise for renewable energy at scale. But they can use a lot of water, which is a problem since they tend to be located in places where water is scarce. Some concentrated solar technologies need to withdraw as much as 3,500 litres per Megawatt hour (MWh) generated. This compares to 2,000 litres/MWh for new coal-fired power plants and 1,000 litres/MWh for more efficient natural gas combined cycle power plants (World Bank, 2013).

a hypothetical future and assess the potential changes based on several risk factors, such as changes in precipitation patterns and increased competition around scarce water resources (Ceres, 2015). Such comprehensive scenarios do still not exist. Due to the local character of water issues, water scenarios should be developed on a basin level. Moreover, these should not only be based on hydrological data but include several risk dimensions, including access or the capacity of local water management bodies to manage water allocation. There are however a few studies that tried to quantify different demand trends and supply projections, as well as resulting water gaps (McKinsey, 2009; FAO, IEA, UN Water, IHA, 2017).

Water is at the core of several international conventions and agreements, including;

- **The Helsinki Water Convention:** The "Convention on the Protection and Use of Transboundary Watercourses and International Lakes" (Water Convention) serves as an internationally legal framework for transboundary water cooperation. Originally it was set up only for the members of The United Nations Economic Commission for Europe (UNECE). Within the region of the UNECE, almost all countries sharing transboundary waters have ratified or accessed this Convention as parties. Moreover, since March 2016 all UN Member States may accede to the Convention (Tchad in 2018). Through setting up specific agreements between neighboring countries, parties are required to prevent, control and reduce transboundary impact, use transboundary waters in a equitable way and ensure their sustainable management of surface and groundwater, including drought and flood management.
- **The Ramsar Convention on Wetlands:** This intergovernmental treaty, with 170 contracting parties, provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. It has so far assigned 2,289 Ramsar sites with a total surface of 225,399,512 ha, more than 54 times the size of Switzerland.
- **The United Nations Framework Convention on Climate Change (UNFCCC):** Within the Paris Agreement and the Conference of Parties (COP) to the UNFCCC, several nations and organisations emphasise the value of water in all climate change related initiatives and dialogue, e.g. under the #BlueLineBonn. They include Germany, the Netherlands, and Morocco, along with the Alliance for Global Water Adaptation (AGWA), SIWI, and members of the #ClimateIsWater Initiative. There are several initiatives under the Lima-Paris Action Agenda that address water and oceans resilience in the face of climate change, including The Business Alliance for Water and Climate or the Paris Pact on Water and Climate Change Adaptation.
- **2030 Agenda for Sustainable Development:** The United Nations have adopted Resolution 70/1 'Transforming our world: the 2030 Agenda for Sustainable Development'. Among the 17 Sustainable Development Goals (SDGs), Goal 6 is to 'ensure availability and sustainable management of water and sanitation for all'. It consists of tackling challenges related water scarcity, access to safe drinking water, sanitation, water quality, flood risks, and transboundary water. Most of the other SDGs also relate to water with water-related targets. In 2016, the UN General Secretary and President of the General Assembly began advocating for explicitly linking the goals and processes around the 2030 Agenda for Sustainable Development and the Paris Agreement. During the COP 23, there were advocates for water to be the mechanism to link, coordinate, and implement the policies and processes between the different sectors and policy domains, including the goals for sustainable cities (SDG11) or food security (SDG2) and climate change (SDG13) (AGWA, 2017).
- **Human right to water and sanitation**: In the Resolution 64/292, the United Nations General Assembly explicitly recognises access to water and sanitation as a human right. Clean drinking water and sanitation are essential to the realisation of all human rights. It also specifies the role of corporations in respecting access to water and sanitation. The

WBCSD invites companies to Pledge for Access to Safe Water, Sanitation and Hygiene (WASH) at the workplace, as well as increasingly in the supply chain and in communities.

In conclusion, water risks can lead to material financial implications that manifest in companies' decreased revenues, increased costs, stranded assets or limited access to equity and debt. These can have ripple down effects to individual securities and portfolios across all asset classes. However, the challenge is to understand materiality and timing of water impacts on specific asset classes, sectors and industries. In comparison with climate change, water conditions can strongly vary over time and location. However, adaptation and mitigation are strongly intertwined with water risk management. So are hydrological water cycles and biodiversity, e.g. while forests may reduce sedimentation, control surface flow and increase groundwater infiltration, they also host a wide range of flora and fauna. According to the recommendations of the TCFD, companies and investors alike should consider water-scenario analyses in their long-term strategy, growth and cost considerations. However, holistic scenarios and related water-risk associated mitigation paths are currently inexistent. Several multilateral environmental agreements have water at their core and in the stand alone target of SDG6, water is highly ranked within the 2030 Agenda for Sustainable Development. Therefore, water is connected across sectors, other natural resources and international agreements. The following chapters shed light on existing tools and methodologies to reflect water risks in the financial market.

3 Research and analysis

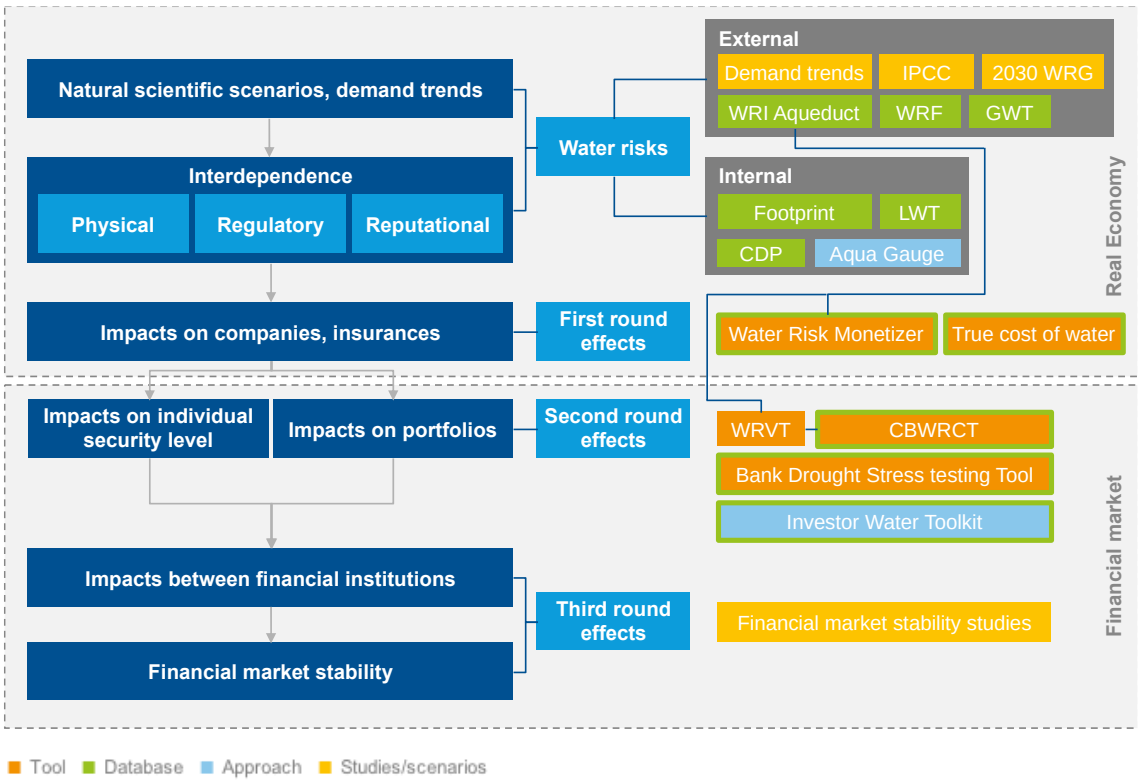
The following chapter gives an overview and evaluates the different data, scenarios, models and tools to display water risks in the real economy (first round effects). It also includes the level of financial products, portfolios, financial institutions and possibly the entire financial market (second and third round effects). Lastly, possible actions in the form of already existing water compatible finance and investment strategies are highlighted.

3.1 Available tools, databases and methods to assess water risks

3.1.1 Overview of assessed tools and approach

The following chapters provide an overview of the available models, approaches and databases. Figure 4 shows the approach and structure of this study for the assessment of available tools. On the left hand side are the different levels of direct and indirect effects of water risks on the financial market, as already shown previously in Figure 2. The right hand side shows the available tools to analyze water risks at different levels. Some tools focus more on assessing water risks in the real economy, e.g. by analysing the hydrological conditions of the basin where a company operates or increased operational expenditures due to water risk. Others do so on the financial market level, e.g. by calculating stranded assets due to drought risks. Therefore the following chapters make this distinction. Notwithstanding, investors may use and combine all described tools when assessing water risks, both for their single securities and portfolios.

Figure 4: Direct and indirect effects of water risks and available tools (Source: South Pole)



On the level of first round (real economy) effects, tools were analysed that allow for quantifying impacts on a company level, such as revenue loss or increased operating expenses by companies.

On the level of second round effects, the study considers models, databases and approaches that are specifically relevant for assessing effects on individual securities, such as private or public equity, as well as credit portfolios. (Nevertheless, investors may also use the other tools.)

Qualitative and comparative method

The following two chapters briefly assess each tool from an objective and descriptive point of view. The qualitative assessment includes the type (dataset, approach, model), internal or external water risk assessment, access and availability, granularity, as well as industries and regions under consideration. What follows is a preliminary compilation of available models, databases and approaches. The focus is hereby on tools that are water specific and where data is available on a global scale. Tools that only apply to a limited region, such as the US, or focus on other Environmental, social and corporate governance (ESG) or natural capital issues were considered to be beyond the scope of this assessment. The conclusion contains a short comparison of the tools with regards to their suitability to assess water risks for the financial market.

3.1.2 Methodological overview and assessment of scenarios, data and tools for the real economy

In what follows, a selection of the most relevant data sources, tools and methods for the real economy is described in greater detail. These tools mainly target the level of individual companies, such as analysing the hydrological conditions of the basin where a company has its facility or how well a company manages water risks. Notwithstanding, investors may also use and combine these tools for all relevant asset classes when assessing water risks.

Data and Scenarios

Water Footprint data

A water footprint is not a risk assessment. However, it can provide important insights on the internal risk factors of a company or a sector, namely the sectors' dependency due to water uses and pollution.

The two major competing methodologies are the Water Footprint and the ISO 14046. On the one hand, the Water Footprint methodology focuses on quantitative volumetric indicators. They relate to blue (volume of surface or groundwater that has evaporated or been consumed, e.g. when water has been incorporated into the product), green (volume of rainwater that plants have lost through evapotranspiration) and grey water (volume of polluted discharge water). On the other hand, the ISO 14046 water footprint focuses on potential environmental impacts related to water and includes relevant geographical and temporal dimensions. It includes four phases: goal and scope, inventory accounting, impact assessment and interpretation. Quantitative impact indicators are at the core of the impact assessment phase. Therefore, this approach focuses more on a life cycle approach, with a water degradation footprint (water quality related to acidification, eutrophication or ecotox) and a water availability footprint (quantity). The assessment of volumes is therefore not sufficient.

There are inventory databases that entail both quantity and quality aspects. These include the Water Footprint Network's WaterStats, Ecoinvent or Quantis' Database. All are global in spatial reach and distinguish between industries and commodities. E.g. the WaterStats covers 120+ agricultural commodities, and has strong peer reviewed data. The data for footprint and scarcity is based on monthly consumption. The datasets are free and cover product water footprint statistics, monthly blue water footprint statistics, national water footprint statistics, international virtual water flow statistics, water scarcity statistics and water pollution level statistics.

Investors might find it useful to assess water used per USD of revenue, or wastewater discharged per unit of production. The water metrics of Bloomberg or Dow Jones Sustainability Indices include company reporting. Bloomberg is based on total water consumption (m^3/year), water consumption per unit of production as well as total recycled/reused water (m^3/year). The Dow Jones Sustainability Index (DJSI) focuses on total water withdrawal (m^3/year), municipal water withdrawal (m^3/year) and total water withdrawal from other sources (m^3/year). Also CDP Data contains self reported water accounting metrics. Global Reporting Initiative (GRI) (with its Sustainability Reporting Standards) is generally referred to as the recommended standard.

Future Water Demand and Supply Scenarios

There are various studies on trends regarding water demand and supply. For example scenarios of increased water consumption in the power generation sector or due to increase of the population also in the agricultural sector (IEA, UN Water, IHA, 2017). These are exacerbated through climate change induced changes of extreme weather events and water conditions (IPCC, 2014).

Furthermore, the 2030 Water Resources Group (WRG) (a public, private and civil society partnership hosted by the World Bank) shows, that the global freshwater demand will exceed the water deposits by 40% by the year 2030. The study projects a two percent increase of water withdrawal in 154 basins, assuming no changes in productivity and efficiency. This results in a doubling of the demand compared to the year 2005 and a gap that results from the comparison with the today available and reliable water supply (McKinsey, 2009, S. 44). Different water stress scenarios are defined in the WRI Aqueduct tool, where a business as usual (BAU), an optimistic and a pessimistic scenario are considered.

These studies, however, are often built on different assumptions, scopes, geographical focus and underlying data availability. Examples include the quantification of future water need and availability. The WRI relies on the water consumption and physical availability whereas the 2030 WRG is based on water withdrawal and access to water. Nevertheless, despite different assumptions, studies suggest an intensification of water risks in general.

Moreover, often these scenarios rely only on hydrological data. Water security, however, does not only depend on the physical freshwater availability relative to its demand, it is also based on social and economic factors such as planning and management approaches, institutional capacity, sustainable economic policy instruments and incentives of the financial market. Holistic, quantitative and geospatial scenarios of this kind have not yet emerged. The “global water security index” and MIT/WRI’s “Development of Public Water Management Indicators” are a first attempt in this direction (Gain et al, 2016; MIT/WRI, 2017). Therefore, also associated water use reduction paths for production are currently inexistent.

On a corporate level, a very young and state of the art practice include the setting of context-based water targets. They should define corporate goals which make sense in the context of the basin. The “beverage industry environmental roundtable” aims to develop a methodology for this purpose by 2019 (BIER, 2017; CEO Water Mandate, 2017). These seem however not to serve for a global reduction path. Even though some companies have defined their water targets, they still lack typical processes that depict water risks in the real economy under the consideration of such global scenarios. This is also a result of the absence of such forward looking scenarios and globally accepted water risk reduction paths.

Company level data from CDP - Open Data Portal

The formerly Carbon Disclosure Project (CDP), is an international non-profit organisation. Now in its ninth year, CDP asks companies on behalf of their investors to disclose corporate information to the CDP Water Program. This includes 639 institutional investors, representing USD 69 trillion in assets. Companies are asked to report on how they are managing business risks posed by worsening water security. Moreover, next to the investor request, companies are asked by their customers to submit information under the CDP Water supply chain program.

CDP water data has the following features:

- The dataset includes a company’s water accounting, water risk assessment processes, facility level and supply chain water risks, water policies and board oversight, targets and opportunities, or changes in operational costs (OPEX) and investments (CAPEX) related to water.

- With South Pole being CDP's official scoring partner since 2015, the companies receive a score from F to A for the third year in a row. The score is based on a peer reviewed methodology. Only the overall scores are publically available, not the breakdown scores, and only if a company submitted a public disclosure.
- The data is self reported and the scoring methodology does currently not evaluate whether the data has been audited by a third party.
- The questionnaire in 2018 will be adapted in order to align better with the TCFD recommendations, e.g. with regards to including scenario analysis and it will feature sector specific questionnaires for Oil & Gas, Electric Utilities, Metals & Mining, Chemicals, Food, Beverage & Tobacco.

CDP provides the Open Data Portal. Around 20 company reports can be downloaded, while for commercial use CDP requires a fee. CDP also provides global water reports, this year it analyses water action trends of 742 publicly listed companies (CDP, 2017). For investor signatories, CDP produces sectorial overviews.

The dataset comprises 2025 companies that have responded in 2017. Each have a ticker and can be distinguished to the level of different sectors. The spatial reach of the data is global. While companies are headquartered either in the US, in Europe or in South Africa, they report water risks throughout the value chain across the globe.

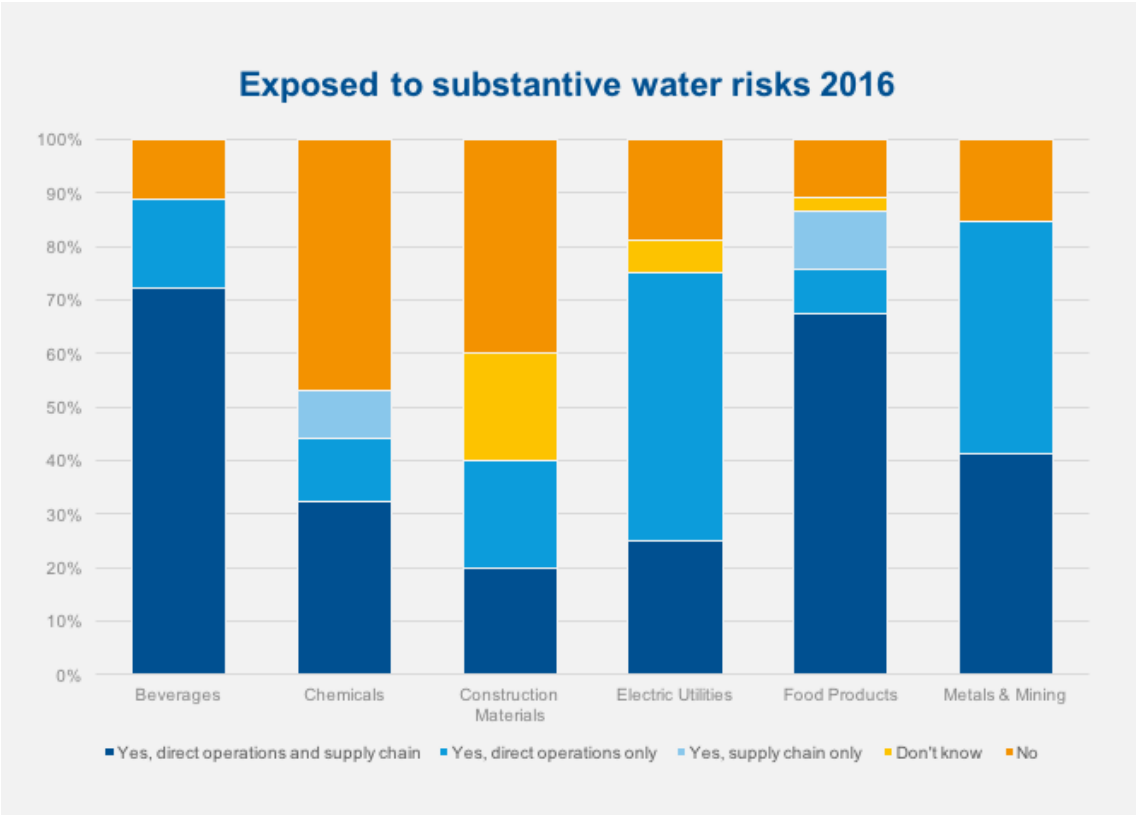
Industry-level water risk assessment based on CDP and CERES

Only very few, advanced companies are starting to assess and manage water risks in a holistic 'water stewardship' way. For instance, while beyond-the-facility interventions become more common to manage water risks, they are often still not undertaken in a collective action approach (Frank et al, 2017). Moreover, such detailed local data on a basin-level is neither consistently accessible nor available. It would require considerable time effort if an investor were to understand each facilities' performance to such granularity. Instead, according to the Investor Water Toolkit (2017), investors find it helpful to asess water risks on an industry level and conduct geographical water risk exposure, before continuing to deeper company related research during due diligence or portfolio analysis.

CDP Data offers valuable insights with regards to the companies' own perception of water risk exposure. Analysing six high impact industries based on their CDP Water Response 2016, South Pole found that on average 76% of the companies report being exposed to substantive water risks as shown in Figure 5 (Frank et al., 2017, p.10). Substantive refers to a financial value of the potential business impact. Most commonly it relates to a change in either the revenue, the produced amount of goods or the bottom line of a company. Companies in the Beverage, Food and Mining industries experience the highest exposure to water risks. Water risks in direct operations and post operations (e.g acid mine drainage) are of main concern to the extractive industry, while supply chain risks are more common in the Food and Beverage sector that depend on agricultural inputs. This includes higher price volatility as well as supply chain disruptions due to unmet water availability or rainfall for irrigation.

The Investor Water Hub and Sustainability Accounting Standards Board's (SASB) defined the materiality of water risks for several industries. Below follows a preliminary overview throughout the industries' value chain. It takes into account the water dependency of industries and value chain composition. The underlying qualitative database is available within the Investor Water Toolkit (2017). For additional sector specific analysis, there are data sources such as WWF Water Risk Filter (WRFs) Agriculture Supply Chain Analysis, SASB sector guides, "Water in the Mining Industry," by NBIM, Columbia Water Center working paper and website on water-related risks of mining or Ceres analysis of 42 food companies' response to water risk (Ceres, 2015).

Figure 5: Sectors reporting exposure to water risks with substantive business impact (Source: South Pole based on CDP 2016 data and Frank et al. (2017))



Tools and models

World Resource Institute (WRI) - Aqueduct

The Aqueduct Initiative features a publicly available global database and an interactive mapping tool to provide information on water risk, including projected change indicators. For baseline risk three categories of water risk are differentiated: Physical Risk Quantity, Physical Risk Quality as well as Regulatory and Reputational risk. These three categories comprise a total of 12 indicators:

Physical Risks Quantity: Baseline Water Stress, Inter-annual Variability, Seasonal Variability, Flood Occurrence, Drought Severity, Upstream Storage, Groundwater Stress

Physical Risks Quality: Return Flow Ratio, Upstream Protected Land

Regulatory and Reputational Risks: Media Coverage, Access to Water, Threatened Amphibians

The geographic reach of the data and the tool is global and the sectoral disaggregation includes eight sectors. These include Agriculture, Food & Beverage, Chemicals, Electric power, Semiconductor, Oil & Gas mining, Construction materials and Textile. Moreover it contains three scenarios for future water conditions, namely: “optimistic”, “business-as-usual” and “pessimistic” based on a combination of representative concentration pathways and shared socio-economic pathways from IPCC 5th Assessment Report,.

The underlying data is based on over 30 different data sources, including data by the Intergovernmental Panel on Climate Change (IPCC) on projected changes in water availability worldwide in 2020, 2030 and 2040. Overall, the tool was developed to help companies and investors understand water-related risk to business, and for other stakeholders to understand water issues. Certain indicators, such as upstream water quality and return flow, will be updated shortly.

Moreover, via Bloomberg, the Bloomberg Map Function (BMAP) allows for an overlay with Aqueducts Water Stress Data. Via the Aqueduct, the data is public and free, an investor may import locations of interest and export the data to an excel sheet. Through the Bloomberg Terminal, it is a paid service, with the advantage that an investor can directly populate Bloomberg's database of facility and sourcing locations, and overlay these corporate locations onto the map. Linking asset level data/GPS to water risks has to be considered carefully, as often only Headquarter data is available and not necessarly the relevant asset level data. The Headquarter's exposure to water risks might not be as relevant as the exposure of other assets of a company.

The Aqueduct serves as input data for other tools, such as the Water Risk Monetizer by developed by Ecolab and Trucost, as well as for the Water Risk Valuation Tool by Bloomberg and the Corporate Bonds Water Risk Credit Tool by The Natural Capital Declaration (NCD), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the German Association for Environmental Management and Sustainability in Financial Institutions (VfU).

World Wildlife Fund (WWF) - The Water Risk Filter

The tool developed by the World Wildlife Fund (WWF) called the Water Risk Filter is aimed at companies interested in assessing water related risks for operations, suppliers or growth plans. Investors or creditors can use the risk assessment to help identify potentially significant risks for themselves or their clients and therefore return on investments.

The tool is based on responses to a questionnaire covering water-related issues including water quantity and quality. The tool divides the risk assessment into three overarching topics:

- The first topic "Basin related risk indicators" contains six risk categories: Physical risk - Quantity (scarcity), Physical risk - Quality (pollution), Physical risk - Ecosystem threat, Physical risk - Dependence on Hydropower, Regulatory risk and Reputational risk, which again contain a total of 20 different indicators.
- The second topic "Company related risk indicators" is subdivided into seven risk categories, containing a total of 37 risk indicators. The categories include Physical risk - Quantity (scarcity), Physical risk - Quality (pollution), Physical risk - Supply Chain, Regulatory risk, Reputational risk, Benchmarking & Comments, Hydropower specific indicators
- Finally, the third topic "Commodity related risk indicators" is consists of of six risk categories, which again contain 30 individual risk indicators. This shows the granularity of this tool, where water risk scores range from 1-5, from no risk/very limited risk to high risk.

The Water Risk Filter is publicly available, and covers 34 different industries as well as over 120 agricultural commodities, each with specific weightings and underlying data on withdrawal, consumption and pollution. The spatial reach of the tool is global, the spatial resolution is particularly high in risk assessments for South Africa, Brazil and Great Britain.

WWF claims, that this tool could be used by financial institutions and investors to assess water risks at company and portfolio level in the future if companies that use this tool publically disclose their output data (WWF, 2011, p. 47). But this is currently not practice, as this kind of data is not disclosed by any company at the time.

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

The Global Water Tool (GWT) is a free and publicly available tool aimed at companies. The tool does not provide direct risk factors, instead it provides companies information on water availability, sanitation, population and biodiversity on a country and basin-level. It may serve as a primary indication to identify corporate water risks and opportunities:

- First, it includes a workbook that consists of data input, inventory by site, key reporting indicators and metrics calculations.
- Second, the tool involves a mapping function to plot sites with a small set of country level and basin data points. They are, however, based on the input from the user. Moreover, for scarcity, the data is based on annual water withdrawal instead of consumption. At country level the data points include: Total renewable water resources per person, Total water withdrawal per person, Dependency ratio, Industrial water withdrawal as part of total, Population served with improved water, Population served with improved sanitation. At basin-level data includes: Annual renewable water supply per person, Biodiversity hotspots, Production by Annual Renewable Water Supply.
- Third, a Google Earth interface that allows spatial viewing.

The sectoral disaggregation encompasses the categories “Industrial”, “Office/Retail” and “Supplier”. However, WBCSD also offers various industry-specific separate tools. Overall, companies can compare different sites on a global scale and explore levels of current and future risk exposure in water-scarce areas.

Global Environmental Management Initiative (GEMI) - Local Water Tool

The Global Environmental Management Initiative (GEMI) developed the Local Water Tool in cooperation with the WBCSD and its Global Water Tool (GWT) as presented in this section as well. The aim of the tool was to help companies and other organizations identify the external impacts, business risks, and opportunities related to water use and discharge at a specific site or operation. But it should most importantly help companies to create site-specific local water management strategies. Risk dimensions include physical, regulatory, social, competition, climate variability. In particular, the tool encourages businesses to take a number of actions, including:

- Identifying water-related risks and opportunities
- Assessing the business case for action
- Developing a water strategy
- Ensuring that water-related opportunities and risks are tracked and managed effectively

The tool is applicable to all sorts of industries, whereas an industry-specific tool exists for the oil and gas industries. The spatial applicability is global, however the assessment of local situations is primarily based on user input via the questionnaire.

Ecolab - Water Risk Monetizer

The tool called Water Risk Monetizer was developed by Ecolab in partnership with Trucost and Microsoft. Companies can use the tool to assess the potential impact of water scarcity on costs and production. Thereby, mainly two risk aspects are taken into consideration: On the one hand, the tool evaluates incoming water risks, meaning the quantity and quality of water that is required for production or processing. On the other hand, the quality of outgoing water risks is considered. These two risk aspects cover thus water availability, water quality and competing uses of water within local basins across various time horizons.

The tool requires a large amount of the information to be entered by the user. However, the tool also relies on databases such as industry average data and local water basin information from the WRI Aqueduct tool, population data, water quality standards, or data of environmental impacts by Trucost. There is a drought scenario feature that estimates financial risks from droughts.

The tool calculates a water risk premium to the existing water price. The Water Risk Monetizer 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. It measures a shadow price on the companies, and can help to assess these on a portfolio level. The tool helps to understand the potential revenue at risk or increased operating costs due to the impact of water scarcity or quality on operations. Investors can also use it to understand changes in business value or credit risks for a company.

The tool is publically available and for free. The developers claim that the Water Risk Monetizer is globally relevant and applicable across a wide range of businesses and industries, investors may be used to compare risk profiles across sectors and locations.

Veolia - The True Cost of Water

Veolia Water Technologies developed a tool to estimate the “true cost of water” to help companies mitigate production risks whilst at the same time optimising their environmental impacts. It also counts as a shadow pricing tool. The tool combines three types of costs, where for the latter, various risks are considered: Direct costs, which entail the price of water, operational costs (OPEX) and investments (CAPEX) in water infrastructure, indirect costs, which comprise administrative, legal and corporate social responsibility costs, and last but not least costs related to risks. The risks that are taken into consideration are the following:

- Operational costs, e.g. water shortages
- Financial costs, e.g. increase in cost of capital
- Regulatory costs, e.g. obligations to meet ecological standards
- Reputational costs, e.g. temporary loss of license to operate, boycott

The tool also includes the option to estimate the costs of mitigating the above-stated water risks. The availability of the tool is limited in that only clients of Veolia can access it. Overall, it is not aimed at a specific industry or region and can be applied in a variety of industries as well as regions.

Ceres - Aqua Gauge Tool

The Aqua Gauge Tool was developed by Ceres, the World Business Council for Sustainable Development, Irbaris and the Investor Responsibility Research Center (IRRC) institute in consultation with over 50 investors, companies and NGOs. It is an Excel-based assessment tool and allows investors to grade a company's corporate water management against leading practice - via a score card. Benchmarks include "no practices" to "beginning practices," to "advanced management practices."

The user completes a questionnaire, usually with data from CDP, CSR reports or a company’s website. The multiple choice questions address four areas: A company's water risk measurement and management practices, stakeholder engagement and disclosure.

The Aqua Gauge Tool does not perform a risk assessment of single types of water risk. Instead it helps assessing the water risk management strategy of a company. It can give indications of how mature a company is with regards to managing water risks, e.g. provide indications on internal factors. However, emphasis is on a corporate level rather than on a local facility or basin-level. The tool does not target a specific industry or region and can therefore be applied widely.

3.1.3 Methodological overview and assessment of tools and models for the financial market

The following tools were developed with an intent to quantify potential impact of water risks on individual securities, portfolios of securities or even the full financial market.

Bloomberg - Water Risk Valuation Tool (WRVT)

Bloomberg provides a high-level demonstration tool that aims at integrating water risk into company valuation in the gold or copper mining sector. Adapted from the Carbon Risk Valuation tool, WRVT employs a discounted cash flow technique. It quantifies the effect of a stranding asset scenario due to future physical water scarcity on revenue and costs. The tool also estimates the effects of water risk on earnings and share prices.

The tool was developed in collaboration with the Natural Capital Declaration (NCD), which was signed by the CEOs of more than 40 financial institutions, entailing their commitment to the eventual integration of natural capital considerations into financial sector reporting, accounting, and decision-making. The part of the tool that was developed by NCD is publicly available. However, only via the Bloomberg terminal does the excel contain somce corporate location and financial data of the company.

Besides the contributions by the NCD, the data used in the tool includes data from the WRI Aqueduct Initiative, a data source introduced in this section as well. The tool covers physical risks by means of water scarcity as well as regulatory risks. There are two pathways on how water risk is considered in the tool: On the one hand, on the revenue side the value of potentially unextractable ore due to water scarcity is calculated. On the other hand, on the cost side the shadow price of water is calculated based on a Total Economic Value (TEV) framework. This stands for the consideration of numerous factors, such as health, ecology, etc., and the corresponding prices of water in terms of these factors.

In terms of spatial reach it can be globally applied, and could also be adapted and replicated to companies in other industries beyond the mining sector.

Natural Capital Declaration (NCD), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the German Association for Environmental Management and Sustainability in Financial Institutions (VfU) - Corporate Bonds Water Credit Risk Tool

The Natural Capital Declaration (NCD), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the German Association for Environmental Management and Sustainability 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.

Within the project that was commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ), the water valuation approach based on a Total Economic Value (TEV) framework was developed, which is also applied in the WRVT by Bloomberg and is publicly available. The TEV framework is used to calculate the so-called shadow price, which is a denominator of the value of water to other services. The shadow price serves as a proxy for water risk in the context of the Corporate Bonds Water Credit risk Tool and helps to evaluate company-level water risk to benchmark company results against peers.

Other common elements between the WRVT and the Corporate Bonds Water Credit Risk Tool are the use of the Aqueduct Water Risk Atlas data on water quantity by the World Resource Institute (WRI), including projected changes in water supply, water demand, water stress, etc. This helps to identify companies that depend heavily on access to water in locations that are exposed to water stress. It applies a strong physical risk focus, not taking into account regulatory or reputational risks or water quality issues.

Finally, the tool enables users to quantify the potential impact of water scarcity on the company's creditworthiness. The tool can be used globally.

Natural Capital Finance Alliance (NCFA) - Drought Stress Testing Tool

The Drought Stress Testing Tool was developed by the Natural Capital Financial Alliance (NCFA), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), the Emerging Market Sustainability Dialogues (EMSD) network, the United Nations Environment - Finance Initiative (UNEP FI), the Global Canopy Programme and Risk Management Solutions (RMS). The tool allows financial institutions to incorporate five drought severity scenarios based on methods used by insurers. It calculates the probability of changes in revenue and operating costs for individual companies. These changes filter through the financial statements of the companies in a lending portfolio, and therefore allow a lender to assess the risk of default both on the individual company level as well as on the portfolio level.

The drought hazard itself is broken down into three impacts, by which altogether the vulnerability towards droughts can be defined. These impacts are, first, the direct impact on a particular sector due to the water deficit, second, the indirect impact due to an electric power shortage, and third, the indirect impact due to reduced material or labour supply.

The user needs to insert the debtor financial statement, locations and operating information. It is considered to only require little time to insert this information. The tool should be applicable also to different asset classes.

It is freely accessible via the NCFA site. The tool covers the following four countries: Brazil, China, Mexico and the United States, while the sectoral coverage comprises 19 industries.

Ceres - Investor Water Toolkit

In December 2017, Ceres and over 40 institutional investors managing USD 6 trillion developed the Investor Water Toolkit. It is an online resource that guides investors to integrate water risks into portfolio management and decision-making.

The report-like tool covers sections like understanding water risks, establishing priorities, buy/sell analysis, portfolio and asset class analysis, and investor engagement. It provides graphical illustrations, different data sources, proposed metrics, tool overviews and comparisons and case studies. Ceres even established preliminary databases, e.g. a sectorial water materiality map. It is a toolkit for investors developed by investors themselves.

It presents guidance on incorporating water risks at the level of single securities, such as public equities, corporate bonds, private equities and municipal bonds. Recommendations include to focus on industry-specific and geographic exposure, e.g. during due diligence processes in the the buy/sell analysis. Similar steps are also recommended for portfolio analysis. E.g. the Corporate Water Risk Dashboard proposes the analysis of three key areas:

1. To assess the vulnerability to water risks, investors should understand the company's water resource dependency and also the most common impacts of water risks. Investors should also take into account indicators that both relate to current red flags and forecasting.
2. To assess water resource security in geographical regions important to a company, investors should assess local physical, regulatory and social risks. Investors should take into account indicators that both relate to current red flags and forecasting.
3. To assess the resilience or capacity to mitigate water risks, investors need to understand the company's management responses. This includes whether the company's adequately integrates water issues in future growth strategies, e.g. through board oversight, whether it is insured, it promotes stakeholder engagement or supports sustainable water management.

Impacts of water risks on financial stability and the financial system

Apart from risks for individual investors and financial institutions, environmental risks can possibly also lead to systemic risks for the whole financial market and its stability. To our knowledge, no one has ever developed tools for the potential financial stability implications of water risks. However, in the area of climate change, several studies assessed the link of climate risks, including physical risks, and financial stability, so tools and methodologies used there could also be applicable to water;

- Stadelmann et al. (2016) assessed the link between climate change and financial stability for the German Ministry of Finance. For this, they compared the expected and maximum losses due to climate change, including water-related losses, with the size of the whole economy, the most extreme stock market shocks in history and the size of losses during the last financial crisis (around 2007) when all experts agreed that financial stability was clearly endangered.
- Battiston et al. (2016) assessed the potential size of Stranded Assets due to climate risks within major European banks. They did not only consider direct exposure of banks to assets at risks but also investments between financial institutions that are strongly exposed to climate risks, thereby addressing systemic level of risks.

3.1.4 Conclusion on available tools, datasets and approaches

The amount as well as the variety of data and tools on water risks for actors both in the real economy as well as in the financial market is ever-growing, see Table 1. Various tools and data sources are interlinked. Parts of the services offered are based on inputs coming from other tools and data sources. For example most tools depend on the baseline water stress definition of WRI Aqueduct. However, consistent data is still scarce and risk methodologies are only evolving.

Table 1 provides an overview of existing datasets, tools and approaches. From this overview, we derive the following conclusions on assessment of water risks in general, and specifically for the level of the real economy and the financial market.

Water risks in general: Since investors have only recently started to assess water risks, more water risk assessment tools have been established for the real economy rather than for the financial market. The different services reach from self-disclosed data on water risks in very high granularity (CDP - Open Data Portal) to sophisticated tools taking various risk types and scenarios on a global scale into consideration (WRI - Aqueduct). However, not all tools contain water risk data, some just provide a tool where data has to be entered (such as WFN, Aqua Gauge). The combination of internal and external assessments may give appropriate indication regarding the probability of the manifestation of water risks. For instance, internal factors are a company's footprint as a proxy for water dependency (WFN) or the qualitative evaluation of how mature a company is with regards to managing water risks (Aqua Gauge, LWT, CDP). This can be combined with external factors, such as locations of high water stress (e.g. via the WRF that not only provides basin information but also sector specific information, or the WRI Aqueduct that can even be accessed through the Bloomberg Terminal, thereby allowing to plot company locations onto water stressed areas). Finally, the studies on future water conditions are currently neither comprehensive basin related future water scenarios, nor are they in the form of user-ready databases. However, they may be consulted qualitatively. Some of the tools only assess the water risks that a potential user enters in the course of using the tool, others assess whether a company has taken water risks into consideration, and still others actually examine specific risks carefully.

Real economy water risks: A water risk is quantified through the combination of the probability and the impact. While pure 'water risk' tools focus more on probability, other tools allow to quantify actual (business) impacts. Both the Water Resources Management (WRM) and True Cost of Water tools focus on putting a financial value to water related impacts, notably via shadow pricing. However, in the case of True Cost of Water, it compares the cost of different water strategies for

a single operation, and is therefore more useful for corporates than for investors. In contrast, the WRM is both useful for corporates and investors, as the profit and loss statement of the company receives an additional OPEX line. This is calculated by the amount of the additional water shadow price (as in the difference between the actual price) and the amount of water used.

Financial sector water risk: More tools tend to exist for single securities rather than portfolios. The security-level tools can theoretically also be used to assess portfolios but this would imply high analytical costs. Despite sometimes complex, quantitative calculations, such as discounted cash flows, most seem to be user friendly. Some are accessible through Bloomberg Terminal and rely on WRI. The Water Risk Valuation Tool (WRVT) is also a shadow pricing instrument developed by Bloomberg, but only addresses one sector, namely the mining sector. It is not applicable to a portfolio consisting of companies from many different sectors. Nonetheless, the tool does not assess water risks on a direct company level but rather on a higher investor level in that common financial modelling techniques are applied. As a consequence, the output of the tool involves the identification of stranded assets and the influence of water risks on earnings and share prices. The WRVT builds on the freely available Drought Stress Testing Tool by the Natural Capital Finance Alliance (NCFA), which covers 19 different sectors. However, only four countries are part of the tool's scope. The bank drought stress tool is the only one that allows credit default risk valuation on a portfolio level.

The assessed tools have the following shortcomings:

- They mainly cover physical risks, notably baseline water stress, the equally important reputational and regulatory risks are therefore neglected.
- The quantified higher operating costs through shadow prices are mostly material over the long term, while a company losing access to key markets or locations either due to flooding, water scarcity or opposition from local communities are more pressing to many sectors (Investor Water Tool Kit).
- Most tools depend on facility level reporting or accurate water use proxies, while data is sometimes still scarce, e.g. in the coal industry (China, 2016, S. 18).

Many tools do not seem to focus on stewardship management behaviour of corporates and investors, e.g. the assessment of operating costs will rather foster measures at the facility level, while not necessarily tackling the water risk in the basin.

Table 1: Overview of assessed tools, databases and approaches and how they can be used by investors (Source: Own table, built on Ceres, 2017)

	Tool	Developed by	Type	Type specification	Primarily provides	Granularity	Forward looking	Best suited for	Level	Evaluates Water Risk	Financial data in output	Region	Corporate Location embedded in tool	Access	Sectors
Real Economy	**Footprint**	WFN, Ecoinvent	Database	Identification (measurement of water intensity)	Database	Sector	No	All	Corporate & Portfolio	No, information on internal water management	No	Global	No	Free	All, 120+ agricultural commodities
	CDP Water Data	CDP	Database	Self-disclosed	Questionnaire	Company	From 2018 onwards (scenarios)	All	Corporate	No, information on internal water management	Partly	Global	No	Paid	In 2018, sector specific questionnaires for six sectors
	Aqueduct	WRI	Database	Identification (risks)	Maps, Models	Sector and riverbasin	Yes (scenarios)	All	Corporate & Portfolio	External	No	Global	Partly (if accessed via Bloomberg)	Free	All, with weighings for eight sectors
	WRF	WWF-DEG	Database	Identification (risks)	Maps, Models	Sector and riverbasin	No	All	Corporate	Both	Partly	Global	No	Free	34 industries and more than 120 agricultural commodities
	Global Water Tool	WBCSD	Tool/Database	Identification (risks & opportunities)	Maps, Models	Riverbasin	No	All	Corporate	Both	No	Global	No	Free	Several industry specific tools
	LWT	GEMI	Tool/Database	Identification (risks & opportunities)	Questionnaire	Company	No	All	Corporate	Information on internal water management	No	Global	No	Free	Not industry-specific tool, + for the Oil and Gas sector
	Water Risk Monetiser	Ecolab-Trucost	Tool/Database	Shadow pricing	Model with Dataset	Company	Partly from WRI Aqueduct + drought scenarios	All	Corporate & Portfolio	Both	Yes	Global	No	Free	Not industry specific
	True cost of water	Veolia	Tool/Database	True cost & Shadow pricing	Model with Dataset	Company	No	All	Corporate	Both	Yes	Global	No	Paid	Not industry specific
	Aqua Gauge	Ceres	Approach	Management tool	Questionnaire, Scorecard	Company	No	All	Corporate	No, information on internal water management	No	Global	No	Free	Not industry specific
Financial market	**Water Risk Valuation Tool**	Bloomberg	Tool/Database	Shadow pricing	Financial model	Company, Sector	Partly from WRI Aqueduct + scenarios	Equities	Corporate	External	Yes	Global	Yes	Paid	Mining Sector (could be replicated)
	Corporate Bonds Water Risk Credit Tool	NCD - GIZ - VfU	Tool/Database	Shadow pricing	Model with Dataset	Sector	No	Corporate Bonds	Corporate & Portfolio	External	Yes	Global	Partly	Free	Beverages, power and mining sectors
	Drought Stress Test Tool	NCFA	Tool/Database	Financial risk assessment (company & portfolio)	Scenario Model, Dataset	Sector	Yes (drought scenarions)	Credits	Portfolio	External	Yes	4 countries	No	Free	19 Industries
	Investor Water Toolkit	Ceres	Approach	Holistic (decision-making & portfolio management)	Toolkit	Sector	No	All	Corporate & Portfolio	No	Yes	Global	No	Free	Not industry specific

3.2 Overview of existing investment strategies and possibilities for action

This section examines existing investment strategies that align with international water goals or scientific findings on adequate use of water. In theory, such water alignment strategies or measures could occur at very different levels:

- *Transaction level:* Refers to investments as well as reinvestments.
- *Portfolio level*: Concerns the integration of criteria on sustainable water use in companies as well as sustainable water indices by means of an exclusion approach, a best-in-class approach, a weighting approach, etc.
- *New instruments*: Refers to water funds or blue bonds.
- *Dialogue and integration:* This relates to the dialogue with or the integration of invested companies, sensitisation of the importance of a comprehensive water risk assessment, of a clear water strategy and of an adequate water risk mitigation

In practice, several investment strategies or vehicles dealing with water risks have been developed but the focus is almost exclusively on water risk management and opportunity exploration from a pure business perspective, and does not consist on an alignment with policy goals or scientific recommendations on water use. The report called “An Investor Handbook for Water Risk Integration” (Ceres, 2015, p. 12) contains some general recommendations on water risk management by investors. The report is based on interviews with 35 global asset owners and fund managers with over USD 6 trillion in collective assets under management. They were asked about how they analyse water risk as part of their overall attention to ESG issues, how they collect and track ESG and water data, and how they assess water risks. The report highlights ten recommendations, of which five are strategic recommendations and five are portfolio-level recommendations. The former include recommendations such as “Promote upper management support for ESG and water risk integration”, the latter involve recommendations like “Apply water analysis to risks and opportunities across-asset classes”. All recommendations are based on interviews of investor behaviour and not on scientific recommendations or policy goals, and therefore serve as guideline for investment rather than for alignment in the financial industry.

Another publication called “Financing water: risks and opportunities” (UNEPFI, 2006, p. 4) also contains strategic recommendations for investors on how to deal with water risks, again the findings in the publication are based on financial industry expert interviews and raise no claim at serving as a basis for alignment.

Overall, no clear alignment strategies on dealing with water risks on transaction or on portfolio level could be found. As presented above, there are various tools that give strategic recommendations on how to deal with specific aspects of water risks but they all do not aim at alignment. A good example is the Water Risk Monetizer by Ecolab. This tool advertises that it helps businesses to “Make the case for proactive water management strategies by utilizing risk-adjusted costs to demonstrate potential risk-based return on investment compared to conventional modelling using only market water costs”. Apart from focusing on corporates and not investors, it also clearly does not want to foster any alignment.

Water-related financing instruments, such as water funds or blue bonds, mainly address the sourcing and efficient use of water resource from a pure business perspective, no alignment. The Republic of Seychelles has launched the Blue Bond Initiative, which aims at enabling capital markets to fund ocean-related environmental projects. The initiative emerged from the direct and strong exposition to acidification, warming and declining oxygen levels, which pose a direct risk to its marine and coastal resources (IUCN, 2017). Therefore, any blue bond development in the Seychelles could be seen as alignment of investment strategies with national policy strategies.

Water risks can also be managed by investments in green bonds. The Climate Bonds Initiative (CBI) defined various criteria on the eligibility of water projects for the inclusion in a Certified Climate Bond (Climates Bond Initiative, 2016). The criteria cover the following aspects: water

collection, storage, treatment and distribution, flood protection and drought resilience. Green bonds in itself are mainly used to re-finance existing assets, including water infrastructure, and do not normally bring any price advantage to issuers compared to normal bonds. Thereby, an investment in a water-focussed green bond serves more for ESG reporting of investors, while it can hardly be seen as sign of alignment with higher-level policy goals or science-based targets on water.

In summary, it can be said that no clear alignment strategies to global policy goals or a scientifically proven consensus could be identified. Most water-related investment strategies that have been developed have purely been set up to manage general risks or create new business opportunities but have not been deployed for alignment reasons. It seems that this lack of alignment strategies is not just related to preferences within the financial industry but also the general lack of well-known and internationally recognised policy goals or science-based targets on water. The closest to a benchmark for alignment are general recommendations within financial industry associations on how to deal with water risks.

3.3 Water stewardship as new approach for alignment?

Given the lack of alignment approaches, the development of new ones has to be considered. One of them is Water Stewardship, a concept that you could help to align investments with higher-level policy goals and scientific findings on water risks. It could be conceptualized as an umbrella concept under which different water compatible finance and investment strategies can be developed.

Actually, water stewardship is a concept developed for companies to manage water risks in a more holistic way, it has not been developed for investors.

The approach has been advanced by organisations such as WWF, WBCSD or the CEO water mandate. A water steward understands its water related risks, the causes and the impact of the company on the basin-level, both up and downstream. Water is a shared resource that connects users and ecosystems along a the same drainage of a river. In many cases, not only one but several users share the same risk, for example drought or water contamination that affects both the drinking water of local communities as well as the bottling plant that depends on high quality water. The concept of shared water risks clearly distinguishes water management from water stewardship. The former is about efficiency measures and site-level control, while the latter encompasses water management but extends to basin-level collaboration (AWS, 2014, 95).

Therefore, long term water security is not only dependent on a company's internal measures. For example, if the sinking groundwater level poses a risk then the root cause is not adequately accounted for if a company is becoming ever more efficient in its water management, while all other actors in the basin keep extracting more water than the recharge rates allow for. It is, therefore, important that companies and investors become active beyond the fence of their operations. Due to the shared nature of water resources, many mitigation strategies will require collective action by investors, companies, regional water managers and other stakeholders in the basin (WWF, WBCSD, CEO Water Mandate Guide, 2013). Since 2014, the Alliance for Water Stewardship Standard provides water stewardship guidelines for corporates. While mainly targeting production site interventions and plans, the applying facility also has to take basin conditions into account. It serves for certification purposes and is considered the state of the art practice of water stewardship behaviour.

The above definition of water stewardship behaviour would require investors to consider a complex data basis. It involves, for example, the calculation of a company's performance within the context of its basin. This includes the plant's consumption and contamination of discharge water. Now the company's performance needs to be compared to the "fair share" of total contextual water availability in the basin, for example, taking into account water requirements both for human uses and ecosystems (CEO Water Mandate, 2017, S.10). For this purpose, an

investor would not only need to understand the local conditions and the contextual drivers of physical, regulatory or social-licence-to-operate risks in the basin but also if the affected company recognizes the local interdependence of shared risks and needs of actors and ecosystems. In addition, it is important to understand if a company manages these risks holistically, by engaging up and downstream actors and ecosystems in a collective action approach. For this to happen, a strong public sector engagement is needed to unite all the actors of a basin in e.g. the form of a basin organization.

Often, in basins the relevant data is not available, so a potential role of the public sector could be to monitor the relevant data, and make it available to private investors. Private companies may support the public sector, as they will have interest to improve the database.

4 Conclusion

Notwithstanding the growing number of available tools and their continuous development, the assessed tools show several shortcomings from a public policy perspective. They, for example, mainly cover physical risks, notably baseline water stress, while the equally important reputational and regulatory risks are neglected. Additionally, the quantified higher operating costs through shadow prices are mostly material over the long term, while both real economy and financial sectors are more interested in short term effects like a company losing access to key markets or locations either due to flooding, water scarcity or opposition from local communities. Therefore, the current tools and data are not necessarily suited to engage the private sector for alignment with public water policy goals.

We have not found any existing investment strategies that align investments with internationally agreed water-related goals or scientific findings on adequate use of water. In practice, several investment strategies or vehicles dealing with water risks have been developed but the focus is almost exclusively on water risk management and opportunity exploration from a pure business perspective and the strategies do not pursue alignment. Therefore, no clear alignment strategies to global policy goals or a scientifically proven consensus could be identified. It seems that this lack of alignment is not just related to preferences within the financial industry but also the general lack of well-known and internationally recognised policy goals or science-based targets on water. The closest to a benchmark for alignment are general recommendations within financial industry associations on how to deal with water risks. A potential future alignment approach could be to extend the basin-level concept of Water Stewardship from corporates to investors.

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