Water Risks

Emerging Risk Initiative – Position Paper

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CRO FORUM

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1 FOREWORD

Water risks constitute major challenges – both in terms of threats and opportunities – for society as a whole, and for the re/insurance industry. Yet, they are widely underestimated, disregarded or simply ignored.

The Emerging Risks Initiative (ERI) of the Chief Risk Officer (CRO) Forum has aimed at synthesizing in this publication what water risks represent for the re/insurance industry. Summarized in instructive and simple terms, illustrated with many practical examples, it is a contribution to the CRO Forum's goal of providing best practice in risk management to advance business. In line with earlier papers by the ERI, this publication is a further demonstration that the re/insurance industry is concerned and strives to stay abreast of key social, climatic and technological evolutions.

For each water-related risk examined – scarcity, pollution, health, treatment, conflicts, regulatory and reputational issues – it emphasizes how the insurance and reinsurance industry can offer assistance to customers that are adopting innovative water-related projects or technologies. The paper also shows that insurers and reinsurers can invest in promising projects to promote efficient water management or better assessment of the risks.

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2 EXECUTIVE SUMMARY

2.1 Water Risks: an Increasing Concern

By 2050, the world's population is expected to reach 9.7 billion. It will be 11 billion by 2100. All these people will need water to meet their most basic needs. Agriculture, industry and domestic life rely on the abundant supply of safe water. However, this is by no means guaranteed and unpredictable water quality and availability represent one of the decade's top emerging risks.

Freshwater risk management is complex to assess. Such difficulty stems from the paradoxical nature of water: it is plentiful to many yet its scarcity affects hundreds of millions of people, it is both fossil and renewable, it is freely supplied by nature but its treatment, distribution and wastage have a cost.

Water risks are often underestimated, disregarded or simply ignored. This results in a global lack of preparation for future impacts and has implications for the re/insurance industry, as a majority of water risks represent externalities which are not properly priced or assessed. Consequently, the re/insurance industry is concerned, especially in the following areas:

- Re/insurers will have to respond to a growing frequency and severity of losses;
- Awareness levels could be improved and re/insurers will have a role in increasing understanding;
- As significant investors, re/insurers may foster innovation in water-related domains by directing investments into innovative projects, technologies and asset lines.

The difficulty to assess future water risks is emphasized by the advent of new technologies and big infrastructure projects the eventual effects of which are as yet unclear.

2.2 What Are the Risks?

A number of water risks are considered in this paper, including the impact of scarcity, pollution, water-related illnesses, treatment and topics of social, political and economic interests.

Natural resources are unequally distributed around the world. Physical water scarcity, or the literal lack of water, is gradually worsening in many areas. Economic water scarcity from lack of finance or inadequate water management will lead to the rapid depletion of usable water resources. Such shortages will inevitably have implications in a wide range of insurance lines of business: property, agriculture, casualty, life and health.

Major contamination events, from infrastructure issues or accidents are internationally broadcast and become part of the collective memory. Pollution from industry, agriculture and private usage may result in toxic elements, including heavy metals, chemicals and pesticides, seeping into soil and groundwater. Not only can such events have significant socioeconomic implications, the costs can also be high. Clean-up costs of large scale contamination events can exceed US$1 billion along with other costs such as legal and compensation costs which are often insured.

Some of the world's most threatening epidemics spread via water. Infectious parasites, pathogenic micro-organisms and insect larvae develop in still water, and disease-ridden elements are spread by river flows to unaffected areas. The impact on mortality rates of such contaminations via water are visible in the course of large outbreaks. The probability of occurrence is expected to increase further in the near future due to the proliferation of disease-causing agents linked to climate change and human population growth. The extent of the impact on health of chemicals and micro-particles in water is yet to be assessed. Human health may also be impacted indirectly through crops, fish or livestock that consume contaminated water. Life re/insurers have very large potential accumulation risks in case of pandemics resulting from infectious diseases. Likewise, they could also be seriously impacted by aggravated mortality resulting from large scale contamination of water and food in insured population.

Ensuring clean water supply is a key to socioeconomic development. A failure to deliver or maintain a clean water supply can be inhibiting for any society. Many emerging countries are less capable of treating their water due to insufficient economic means. Water treatment in developed countries is subject to increasingly stringent regulations and quality standards to address pollution. Furthermore, treatment plants are considered as critical infrastructure that can potentially disseminate toxic products on a large scale as a result of human error or terrorist attack. Such a large scale event in a major city could seriously impact the re/insurance industry.

> **"Fierce national competition over water resources has prompted fears that water issues contain the seeds of violent conflict"** [1]
> *Kofi Annan, Former UN Secretary General*

Water issues trigger strong emotional responses in people. Distribution conflicts may lead to social unrest and ultimately even cause inter-state conflicts, as seen in Jordan or in the Nile regions. Major upheaval caused by water risks could be responsible for large scale famines, widespread population displacement as well as impact business performance or access to certain markets. For re/insurers, such conflicts could generate losses under life, health, property damages, business interruption and motor policies.

Reputation risks can be significant for companies found guilty of water mismanagement, encouraging bad water policies or simply failing to deter poor water practices. In addition to potential legal liability, they could lose their license to operate. Water risks are also often aggravated by cumulative effects, which further complicate their assessment. Assessing water's direct and indirect costs, and identifying missed opportunities will reveal the "true" price of water and could lead to the development of new insurance products.

Flood and drought are water risks well known by the re/insurance industry. Since they can hardly be considered as Emerging Risks, they are not in focus of this paper.

2.3 What Can Re/Insurance Bring to the Table?

Using their expertise in risk management, re/insurance companies can contribute to assessing water risks and promoting awareness of the risks and their consequences. Local actors seeking insurance could be encouraged towards long-term planning and to use new technologies or water-monitoring devices to ensure better understanding of their water supplies. New considerations in underwriting could also be directed to favour businesses with efficient water management.

The re/insurance industry represents substantial investment capacity over the medium and long term. It may provide a strong leverage to promote promising or sustainable water projects and investments. It could also use its influence to encourage major infrastructure projects to minimise the impact on water supply and usage.

The entire extent of impacts from water risks on the re/insurance industry is still difficult to assess, nonetheless the vulnerability is already here. With such levels of uncertainty and potentially large impacts, water risks are a major emerging risk for the re/insurance industry and for global society.

3 Introduction

> **"We share water, for better and for worse"[2]**
> *Eric Orsenna, French writer and Academician*

3.1 An Emerging Risk for Global Development

Water is essential to human life, and water security[i] is a critical foundation for social and economic development in every part of the world[3] (see box on page 7). The World Economic Forum (WEF) highlighted its significance by ranking water crises as the second-highest impact risk.[4]

The earth's population is projected to reach 9.7 billion by 2050[5], generating major increases in water demand, exacerbated by economic growth driving more intense usage. Freshwater resources are already highly stressed[6]. With this rising demand, water risks intensify, due to greater chances of contamination, spread of infectious diseases, burst of liability issues and political conflicts. New trends also emerge.[7] Water technologies and projects are further developed, seeking greater efficiency in water infrastructure, or solutions to convert wastewater into a resource. New financial models appear, including more public-private partnerships and private activity bonds (PABs) for water.

This publication does not aim to cover all water risks; abundant literature is already available. It focuses on identifying water risk management aspects relevant to the re/insurance industry and to its clients. The topic being so wide, it intentionally does not provide special focus on pure environmentally linked issues (sustainability, floods, natural catastrophes, droughts, rising sea level from climate change).

3.2 An Emerging Risk for the Re/Insurance Industry

In the context of growing concern towards strengthening regulations and corporate reputation, the re/insurance industry has a major role to play in identifying changes in the risk landscape. Water resources present opportunities and threats on many lines of business as well as on the investment side. Water is acquiring a commercial value as people start assessing the true cost of water.

> **"Water stress is already exacting a price on people and economies"[8]**
> *Junaid Ahmad, Senior Director for Water, World Bank Group*

The wide-reaching complexity of water risks and the subsequent increasing economic implications generate major uncertainty for the re/insurance industry. The frequency and severity of potential future related claims may be difficult to anticipate and quantify. Companies need a comprehensive assessment of their water risk exposure to adapt to intensifications in scale, magnitude and reputation. By encouraging efficient asset strategies and informed financing of water-related projects, the re/insurance industry will play its role in raising awareness of the risks of mismanaging water.

This publication contributes to such aim by providing insights on water risks from various angles: access to water in the face of scarcity, infrastructure / technologies for water treatment, pollution, health and infection challenges, social and geopolitical conflicts, regulatory constraints and reputational exposures. The topics are further illustrated with worldwide practical examples in 'blue boxes' (see Table of examples on page 49).

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[i] **Water security** is defined as "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability."

"There is no substitute for water"[9]

Rattan Lal, Director of the School of Environment and Natural Resources, Ohio State University

Water is plentiful on earth, yet scarcity affects hundreds of million people worldwide.

Only 3% of global water resources are in the form of freshwater (in glaciers, ice caps, groundwater, lakes, soils, rivers, atmosphere and within living organisms); 97% is salt water in the oceans. Humanity does not lack water as such, but faces shortages of freshwater readily available for consumption. This is aggravated by uneven geographical distribution, erratic supplies, and evolving trends in worldwide water patterns.

Water resources: both fossil and renewable

Water moves continuously between different reservoirs, following a natural hydrological cycle. The turnaround time of water is about 10 days in the atmosphere and a few weeks in rivers, which makes it effectively renewable. On the contrary, water replacement in deep aquifers can last for hundreds to thousands of years: it is a non-renewable fossil resource (like oil) when withdrawals exceed the annual recharge. The increasing human demand gradually takes its toll on fossil water: some resources are already depleted at rates far superior to their replacement times.

Water is free, but treatment, distribution and mismanagement have a cost

Access to water from rivers, wells or dedicated infrastructures is generally free but this water is often unsafe if untreated. On a larger scale, industries, services and agricultural structures rely on water as a cheap and abundant resource. Yet they often operate without a clear consciousness of the impact of their individual operations on the environment and on other users. A largely unsuspected price ("the true price of water") includes treatment and distribution, and extends to the cost of leakages, evaporation, contaminations, inefficient usage and wasteful practices.

Water brings life, yet it can kill

Since it sheltered the emergence of life 4 billion years ago, it has been irreplaceable for humans' survival and basic needs (drinking, food, sanitation and dignity). But unsafe waters impact public health through contamination and spread of infectious diseases.

Water: a public or a private asset?

Even though water supply is a key political issue for every government and community, it is often treated and distributed by major corporate companies whose objective is profit. Decision on water management is always a local compromise between the various stakeholders and the society as a whole.

Water is a global issue, yet management is local

Water is at the same time a shared asset and a common cause of risk. It is usable countless times by different actors in different locations, provided that those usages do not impact on its quality or availability for the next user. But unless mutual coordination and respect of others is upheld, sharing water may trigger liabilities and conflicts.

Water projects generate development but may induce concerns

Water supports the dynamics of human societies. Major cultures and civilizations developed in direct proximity to water sources. Good water management greatly enhanced the growth of communities throughout the centuries. The modern city of Singapore for instance owes its wealth to its development based on good water management. New technologies are still being introduced to master water resources: desalination plants, water recycling, nanotechnologies. Conversely, innovation and large projects (dams, river diversions) may induce serious environmental concerns and potential conflicts.

Water is of major importance worldwide, however it is by nature enigmatic and paradoxical. This creates risks for society, which can affect the re/insurance industry and its clients.

4 WATER SCARCITY & ACCESS TO WATER

- Water scarcity is a growing global problem, driven by rapid population growth and cultural shifts such as increasing urbanisation and changing habits.
- Poor water management, conservation and efficiency are contributing to the problem of scarcity.
- To match the global span of the problem and the many forms it can take in numerous sectors of activity, action will be needed at the local, national and international level.
- **The re/insurance industry has an important role to play by raising awareness of water threats and nurturing good practice in water use and management, as well as being a possible source of capital for water projects/infrastructure, particularly in developing economies.**

4.1 Origins of Water Scarcity and Expected Developments

Water scarcity originates from deficiency in water availability to meet the different users' needs, and can take different forms[ii]: usage exceeding resources, limited access to resources due to the lack of infrastructure, to inadequate sanitation or to pollution. Water scarcity results from a complex interplay of multiple factors. The physical absence of water is the most obvious cause, but poor water management and anthropic causes are contributing to a greater and greater extent.

TYPES OF WATER RESOURCES

Different types of renewable water resources need to be distinguished:[10]

- ***Blue water*** is the part of rainfall going directly to rivers by runoff, or infiltrating into the ground to feed the aquifers: it is a major renewable water resource.
- ***Green water*** is the part of rainfall temporarily stored into the upper soil layer, and taken back to the atmosphere by evaporation from the soil and transpiration of vegetation: it is another major renewable water resource.
- ***Ice,*** by melting: it is renewable if new snow compensates each year for the melted part.

Apart from these renewable water resources, ***Fossil water*** stored in aquifers is non-sustainable 'blue-water': groundwater stocks are increasingly tapped into and will eventually run out.

'Blue water' is the main topic of this paper, as it is the only type of water that can be managed.

Natural water supplies are usually erratic[11], caused by strong variability in seasons and precipitation, ice storage and glacial melting. This unequal distribution of water is further aggravated by climate change disrupting water cycles. With uneven consequences around the globe, scarcity is expected to emerge in new places and to worsen.

Yet, water demand is mainly driven by the growth of the human population and is expected to rise by another 40% by 2030. The agricultural sector already accounts for 78% of 'blue water' usage, with globally increasing water needs.[12] The rest is divided between industry (18%) and domestic use (4%). Increasing competition for these different water requirements leads to unprecedented stress on water supplies. To aggravate the problem, countries with local water scarcity might still export most of their water as water-intensive consumer goods.

[ii] **Water scarcity** is defined as "the point at which the aggregate impact of all users impinges upon the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully." (UN, 2003)

Other countries manage their water needs through imports/exports. Tunisia for instance cannot be autonomous: to balance its water and financial budget, it exports water-efficient agricultural products with high market value (olives, dates and oranges) and import cheap high water-consuming agricultural products, mostly cereals.[13]

Population and cultural shifts further intensify the water demand. Expanding urbanisation, increasing living standards and changing dietary habits, towards more water-thirsty crops and meat consumption, are contributing to increased water usage. Doha is a prime example, evolving in a few decades from an uninhabited waterless desert, to a modern city of 1.5 million inhabitants, where water consumption per capita is one of the world's highest.[14]

WATER ISSUES IN CHINA

With a population already over 1.3 billion people, China has huge water requirements.

Rice fields, Ping'an

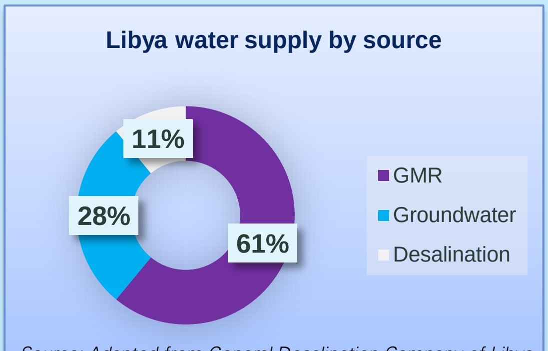
In China, irrigated agriculture covers 50% of the country's agricultural lands and produces 75% of the nation's food.

The North of the country receives little rain whilst supporting the highest demand. Paired with irrigated agriculture that uses large amounts of water, it results in 40% of Chinese cities being confronted with severe water shortages. More than 70% of rivers and lakes are polluted; 95% of rivers flowing through cities are seriously impacted. Lowered groundwater tables can lead to greater groundwater contamination through mobilization and higher concentration of toxic geochemical ingredients of the sediments. As a consequence, these waters are no longer drinkable.

Looking just at Beijing, the surrounding reservoirs containing the city's water reserves are already severely polluted or depleted. Water treatment is insufficient to bring the polluted waters back to a level suitable for drinking. The water table has descended 11m in the past 10 years due to over-extraction of fresh groundwater for drinking and irrigation, generating subsidence in some areas. Resulting base failure can lead to fissures in walls, with the consequence that houses are condemned as inhabitable.

The Great Man-made River project, Libya

Like its neighbours, Libya depends on groundwater for the majority of its water supplies. However, most comes in the form of fossil water – dating back from about 10,000 years ago – from aquifers deep in the desert through the Great Man-made River (GMR) project. The GMR has provided an increasing share of Libya's water in recent years, accounting for 61 per cent of the total in 2009. The 4,000-kilometre network of pipelines, linking massive underground aquifers at Kufra, Murzuq and Sarir with Libya's urban centres on the Mediterranean coast, has also received the lion's share of investment in the water sector, and the participation of international companies was subject to appropriate re/insurance covers.

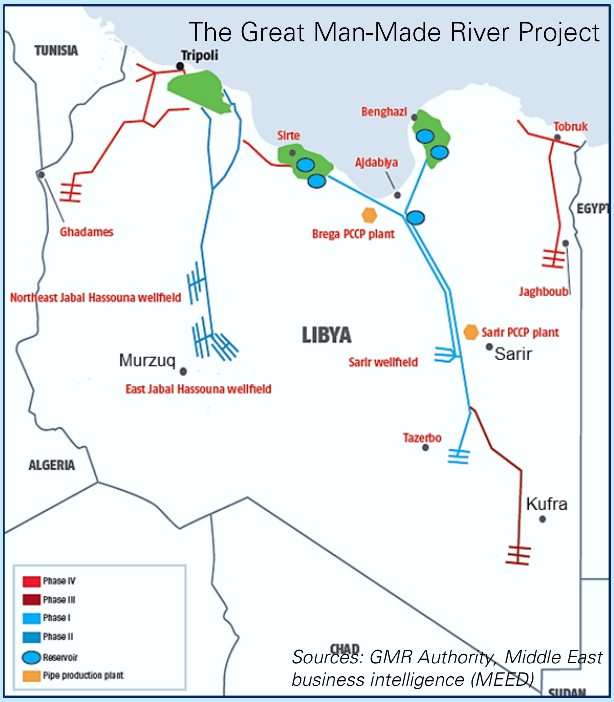


Source: Adapted from General Desalination Company of Libya

Plans for the GMR project were first formulated in the 1980s by the UK's Brown & Root, now part of the US' KBR, a global technology, engineering, procurement and construction company, and Price Brothers, a pre-stressed concrete pipeline specialist. **The delivery of such a large-scale project required high technical expertise (for the design and the execution) that was not available locally, and insurance also gave guaranty in respect of the completion of the works and the liability of "foreign" contractors.**

The plans called for the network to be built in phases. In total, the project envisaged the drilling of some 1,350 production wells spread across the four basins, which would be connected to the coast by 600,000 sections of pre-stressed concrete cylinder pipes. In total, more than 4,000 kilometres of pipeline were to be laid, delivering over 6 million cubic meter of water per day after significant water leakage along the line in the desert. The project is composed of 4 phases spread in time and geographically. There are 5 main reservoirs in the projected scheme with a planned capacity of 15 and 24 million cubic meters for the largest ones.

In sections already built, very important leaks occurred from the pipes, which were unnoticed as the water infiltrated into the sand.



Sources: GMR Authority, Middle East business intelligence (MEED)

In addition, the GMR infrastructure sustained damage during the civil war, most notably the Brega PCCP plant, which was hit by Nato airstrikes in July 2011.

In the immediate aftermath of the civil war, it was unclear how much priority the new government in Tripoli would attach to completing existing contracts on the GMR, or to awarding outstanding work. The GMR always was a highly political project for Gaddafi, who described it as 'the eighth wonder of the world'. It is unlikely to be abandoned completely, given the vast sums already invested in it and its growing contribution to water supply. If future investment is not forthcoming, then an alternative water production strategy will need to be developed quickly.

If the project is not combined with adequate sewerage system and water treatment plants, Libya may still face growing water shortages, due to the non-renewable nature of the aquifer.

4.2 Water Scarcity Induced by Unsound Water Management

Inadequate water management often impedes a sustainable use of water (see Libya example on page 11). It usually stems from lack of technical expertise, short-term planning, insufficient understanding of resources, lack of efficient monitoring, or lack of financing.

Sometimes, infrastructure development may not be robust enough to absorb growing needs (see São Paulo example on page 13). Pipe leakage, evaporation and losses during transportation greatly affect the amount of water delivered to the population, seriously compromising the effectiveness of the project. Bangalore, India's third largest city, is one example with half of the drinking water lost through antiquated plumbing systems.[15]

Sanitation infrastructures are failing as well. In the world, 2.6 million people die each year due to the consumption of polluted water as a result of lack of or inappropriate sanitation.[16] In Cairo, the increasing amount of untreated wastewater discharged into the Nile means the river may no longer be large enough to dilute contamination to safe levels. The effect will impact not only Cairo, but the Nile Delta and irrigation of crops.

Even with good transportation systems, short-term planning is still an issue. This can lead to noticeable impacts such as decrease in river flows (the Colorado River now tends to dry out before reaching its delta), or excessive groundwater withdrawal that exceeds recharge capacity. This results in high concentration of contaminating elements and salinity, forest dieback and land subsidence. In Miami, as a result of excessive pumping the Biscayne aquifer is already a victim of saltwater intrusion from the Atlantic Ocean, which could make the source unusable in the future.

Last but not least, corruption aggravates the lack of proper investments by diverting up to 10% (US$75 billion) of the total amount invested, from international agencies, governments, private companies, local authorities and communities.[17]

DAMS

Dams once stood as the solution to water scarcity, irrigation being their more common purpose. More than 45,000 have been built, on 70% of the world's rivers. However even if they offer a solution to stabilize the amount of water available, this does not entirely preclude scarcity risks.

Dedicated infrastructures such as dykes and dams can also accentuate environmental degradations through modifications of natural water flows, disruption of the distribution of sediments along river beds and deterioration of water quality from prolonged stagnation.

Yaté Lake is the largest reservoir of freshwater in New Caledonia.

The construction of the hydroelectric Yaté Dam in 1958 created this artificial lake, with an area of 40,000ha. The forest of dead trees submerged during this deliberate flooding is now known as 'the Drowned Forest' and still visible in periods of low water levels.

Other impacts include cultural losses and resettlements of people, agriculture or industries.

São Paulo Water Crisis, Brazil

São Paulo, one of the world's largest cities of 20 million people, was affected by a severe drought in 2014-2015. It has been described as the city's greatest water crisis in over 80 years. Since 2014, levels of rainfall have fallen far below average levels, leading to water shortage and extremely low water levels in reservoirs. In early 2015, some fresh water reservoirs reached levels under less than 5% of their maximum capacity, and by February many of the city's residents were subjected to sporadic water cut-offs.

The lack of rainfall may have been linked to the ongoing deforestation in the Amazon basin. The Amazon rainforest exports water vapour via aerial rivers, which bring humidity from the Amazon basin to south-eastern Brazil. It has been suggested that deforestation compromises this 'biotic pump', ultimately resulting in reduced rainfall. This may be further exacerbated when urban heat islands and heat waves prevent the arrival of humid air masses that generate rain.

Yet the 2015 water crisis was not only about a lack of rainfall. According to a government report, more than 30% of São Paulo's treated water is lost due to leaky pipes, fraud and illegal access. Furthermore, insufficient protection of watersheds and reservoirs often leads to pollution of the remaining water sources. Short-term planning further aggravate the situation.

Since Brazil is highly dependent on hydroelectric power, the drought also impacted energy generation and supplies. Several cities were hit by blackouts compounded by high demand for air conditioning as temperatures soared over 35°C. In response, utilities burned more fossil fuels, adding to the cost of energy and greenhouse gas emissions. Brazil's agricultural sector was also affected by the drought, with repercussions on global commodity prices (e.g. for coffee beans).

The water crisis in 2015 led to 12-hour water cut-offs every day for 9 million of the poorest people in São Paulo. This led to massive demonstration against water rationing and shortages.

Heavy rainfall in late 2015 and early 2016 – driven by the El Niño climate phenomenon – has ended the drought for the time being. However, as long as the underlying problems remain unaddressed, it will only be a matter of time before severe water shortages return to São Paulo.

Water scarcity in urban areas may trigger violent social unrests which represent potentially substantial claims for re/insurers.

4.3 Impacts and Consequences for the Re/Insurance Industry

Water scarcity risks arise as a complex interaction of social, economic and environmental factors. Often the scarcity issue results from inappropriate management of the available resources. While the most obvious consequence of water scarcity is on society, it generates exposures for the re/insurance industry as well. Such developments will take time to impact re/insurers, but the vulnerability already exists. Economic losses seem unavoidable in many areas such as property, agriculture, life and health, even if direct insurance losses are hard to predict.

Direct effects may be felt in the agriculture sector and in its upstream supply chain, where water-related products could be affected by more severe or more frequent scarcities. The impact will be further amplified by the increasing demand for irrigation.

For the energy sector, if power plants cannot be cooled due to lack of available water, losses will be certain. Power shortages and widespread blackouts may be felt all along the power grid, leading to potential business interruption losses. The lack of water can also locally be responsible for the reduction of hydroelectric production.

More frequent liability claims might also impact water transportation and distribution companies due to allegations of improper delivery of water and contamination (see Flint example on page 23).

Developed countries suffering water scarcity often compensate with expensive investments and implementation of modern technologies (see Qatar example on page 15). Developing countries on the contrary often lack the technical or economic capacity to adapt. Progress could be encouraged by favouring new strategies in managing water risks.[18] For instance, the agriculture sector is progressively gaining precision by integrating satellite data to monitor water supplies. By providing incentives via risk-adequate coverage prices, the re/insurance industry can play its part in reducing the vulnerability to water scarcity and in encouraging more efficient water management.

On the investment side, re/insurance companies may find an opportunity to diversify their portfolio towards water-efficient assets. This would not only highlight sound corporate responsibility but also enable stronger economic growth (see Figure 1) and will generate potential positive pay-offs in the long-term.

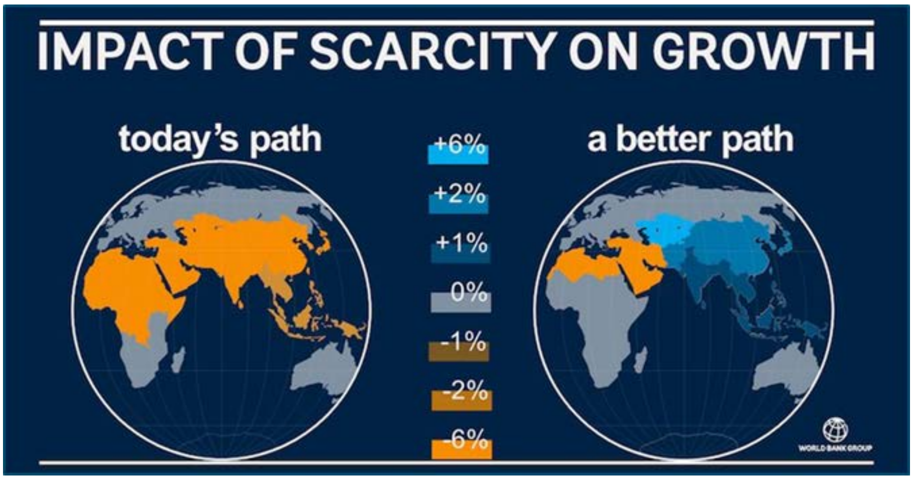


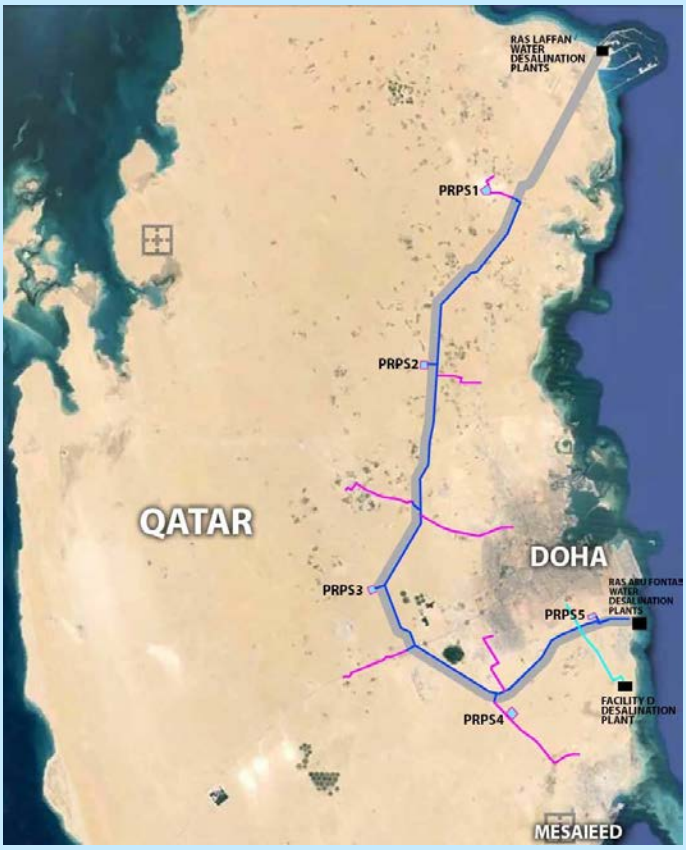
Figure 1 Global water scarcity impact on GDP[19]

Note: The left drawing shows the estimated change in 2050 GDP due to water scarcity under a business-as-usual policy regime. The right drawing shows the same estimate, under a policy regime that incentivizes more efficient allocation and use of water.

Water Security Mega Storage Reservoirs Project, Qatar

Project Background and Objectives

Due to the continuous growth and development in Qatar, and the consequent forecast increase in water demand, Qatar General Electricity & Water Corporation (Kahramaa) is implementing the Mega Storage Reservoirs (MSR) Project. Its purpose is to provide a minimum of 7 days Strategic Water Storage within its network.



The MSR Project will construct water storage reservoirs at 5 new Primary Reservoir Pumping Stations (PRPS), which are located in the vicinity of the Qatar National Utility Corridor (QNUC). The new PRPS sites are connected to existing and future desalination plants through large diameter pipelines (Corridor Mains) that are to be constructed within the QNUC.

This project is seen as the largest water security project ever taken, which may influence how other countries may implement strategic water supplies for their population.[20]

For this type of international contracts, with technological concerns as for materials and equipment, a comprehensive insurance cover with a solid reinsurance scheme is necessary to offer certainty to the completion of works.

Also, international reinsurance facilitates and secures the implementation of such a mega contract by providing warranties in regards of different types of risks/hazards that cannot be supported solely by the owner or the contractor.

Project Description

The project entails construction of 5 drinking water mega reservoir sites and interconnecting network of water pipelines. Each reservoir site will ultimately comprise up to 9 reservoirs, which will be the largest of their type in the world. The project cost is estimated to be QAR17 billion (nearly EUR4.15 billion).

The first phase of the project will deliver storage capacity of about 12.3 million cubic meters of water in 24 huge concrete reservoirs, each as big as nine football pitches.

About 600km of pipelines with diameter up to 1.6m and total weight of around 510,000 tons or 70 times the weight of the Eiffel tower, will connect the different sites and desalination plants.

The second stage of the project will be implemented after 2020 and will include construction of additional pipelines and 16 new reservoirs within the 5 mega sites to achieve an ultimate total storage capacity of about 17.3 cubic meters of water.

Insurance/reinsurance is a mandatory milestone in the execution of water supply projects requiring modern technologies, as they are becoming larger and far more complex.

5 WATER & POLLUTION

- Water pollution is an endemic and growing issue.
- Sources of water contamination are from industry, agriculture and urbanisation.
- **Re/insurers can help through products such as Environmental Impairment Liability insurance, which help to publicly underscore a company's commitment to environmentally sound practices, whilst also reducing its exposure to liabilities.**
- **Insurers can also contribute with valuable expertise, helping their clients identify and correct deficiencies in their systems and processes that increase the risk of, for example, an accidental spill.**

5.1 Diffusion of Pollution into Water Bodies

The hydrological cycle, or water cycle, describes the continuous movement of water on, above and below the surface of the Earth. As part of this cycle, 'blue water' circulates on earth from the land to the sea. Surface runoff gradually flows into streams and rivers, whilst some water infiltrates downward into the soil, to groundwater (see Figure 2). Any contamination of these water bodies with chemicals or other foreign substance, usually caused by human activity, is called water pollution (see Table Top 10 contaminated sites in the USA on page 17).

The pollution of natural water can be divided into three categories; pollution from industrial production, from agriculture, and from private households/residential areas. Over 80% of sewage in developing countries is discharged untreated. Rivers, lakes and groundwater are polluted due to inadequate water quality, sanitation and hygiene.

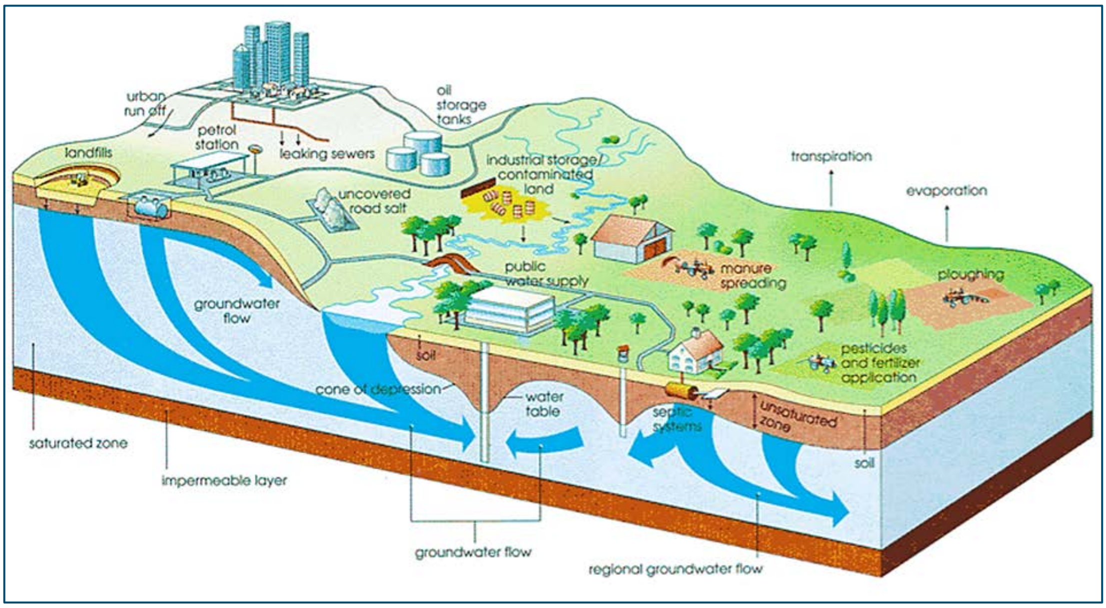


Figure 2 Diagram of the hydrological cycle showing groundwater and surface water relationships along with groundwater pollution risks[21]

TOP 10 CONTAINMINATED SITES IN THE USA

Water pollution incidents of critical severity affect ecological life and threaten human health. Clean-up costs are worth billions and **insured losses can reach up to hundreds of million dollars**. In most cases, clean-up activities are still ongoing, thus the costs are still not fully known.

Site	Period of contamination	Description	Estimated economic costs, not actualized
Enbridge Energy Kalamazoo River Oil Pollution	2010	Oil spill into the Kalamazoo River when a pipeline burst.	Costs are expected to reach approximately US$1 billion.
Hudson River PCB Pollution	1947 to 1977	Pollution of the Hudson River with PCBs.	Cleanup a river will cost about US$460 million.
Portland Superfund Site	More than 100 years	Contamination of this site came from regional development (urban, industrial and agricultural), ship building and ship scrapping.	The costs for cleanup could exceed US$1 billion.
Fox River	1954 to 1971	Risks to humans and wildlife posed by PCBs in bottom sediment, banks, and shoreline areas.	The total cleanup costs and damages for the Green Bay Site are expected to exceed US$1 billion.
Tennessee Coal Powerplant: Fly Ash Spill	2008	An ash dike ruptured. 4,200,000 m^3 of coal fly ash slurry was released.	In its reports to the US Securities and Exchange Commission, the Tennessee Valley Authority projects that its spending related to this loss will total US$1 billion, of which some US$655 million is insured.
Golf of Mexico Deepwater Horizon Oil Spill	End of March 2015.	High-pressure methane gas from the well expanded into the drilling riser and was released onto the drilling rig, where it ignited and exploded, engulfing the drilling rig.	Cumulative charge associated with the spill, before taxes, could rise to US$54 billion from US$44 billion.
The Stringfellow Acid Pits	1956 to 1980	A toxic waste dump. The most contaminated site in California.	Clean-up costs are still growing in 2016 and could reach up to US$700 million.
Iron Mountain Mine Superfund Site	1983 to 2009	The mine discharged an average of a ton a day of toxic metals into the Sacramento river.	Clean-up costs could approach US$1 billion.
PCB Anniston Plant of Monsanto	1929 to 1971	Contamination with PCBs.	The settlement was valued at approximately US$700 million.
Tronox Superfund Liability Claims		Contaminated properties in 22 states.	US$270 million to fund the clean-up of contaminated sites.

Note: PCB: polychlorinated biphenyls

Sources: EPA[22], USGS[23], Californian Department of Toxic Substances Control[24], et al[25]

5.2 Pollution from Industrial and Energy Production

Producing pollutants is harmful to people and to the environment (see List of typical pollutants in Appendix on page 50). As such, industry is a huge potential source for water pollution. Toxic substances can be released directly into water streams or seep through the soil to the groundwater, both as a result of normal operation or after a major accident.

Supply or disposal facilities, storage or production plants can be involved. The main human activities accountable for major water pollutions are mining/quarrying activities (see Ajka example on page 19), manufacturing industries, production/distribution of electricity and construction (see Table 1). Oil contamination also often occurs from extraction operations, fuel stations and refineries. Non-remediated industrial sites, underground storage or waste disposal can discharge highly toxic pollutants into the environment and need close long-term monitoring and maintenance.

Table 1 Generation of wastewater by main industry type in million m^3 (2011)[26]

	Mining and quarrying	Manufacturing industries	Production and distribution of electricity	Construction
Austria (¹)	:	889.6	363.3	:
Belgium (²)	42.0	239.9	7.9	0.4
Bulgaria	12.5	91.3	37.9	0.6
Croatia	1.7	81.4	0.5	:
Cyprus (⁵)	:	1.9	0.0	:
Finland	:	14.4	26.5	14.7
Germany (¹)	227.6	1 180.6	75.4	0.6
Hungary (⁴)	17.8	129.7	3.9	0.0
Latvia (³)	5.5	20.2	6.1	1.3
Lithuania	0.6	33.9	2.6	0.7
Poland	342.9	484.6	79.8	6.6
Romania	47.3	:	:	3.6
Slovakia	20.5	163.0	7.9	0.1
Slovenia	0.1	42.8	:	0.1
Spain (¹)	47.2	602.0	:	:
Sweden (¹)	26.0	839.0	14.0	:

Note: (¹) 2010; (²) 2009; (³) 2007; (⁴) 2006; (⁵) 2005. Source: Eurostat

Industrial risks may be subject to stricter legal obligations because of the intrinsic hazard involved under normal operation. In the European Union, more than 10,000 industrial plants where dangerous substances are used or stored in large quantities have compliance requirements with the Seveso Directive, a legislation on the prevention and control of industrial risks. The adoption of this directive was prompted by an accident in the Italian town of Seveso in 1976.

EMERGING CONTAMINANTS[27]

"Contaminants of Emerging Concern", also called "Emerging Contaminants", derived from industrial, agricultural and urban wastewater sources are increasingly present in waters worldwide: Two types can be distinguished:

- Release of chemical or microbial contaminants to the environment has likely occurred for a long time, but may not be recognized until new detection methods are developed.
- Synthesis of new chemicals or changes in use and disposal of existing chemicals can create new sources of contaminants.

Historically not considered as pollutants, they are not commonly monitored. However, many Emerging Contaminants are now suspected to cause adverse ecological and human health effects, with an impact not yet fully understood.

Ajka Alumina Sludge Spill, Hungary

In October 2010, an environmental disaster occurred at the "Ajkai Timföldgyár" alumina (aluminum oxide) plant in western Hungary. The failure of a dam wall at a waste reservoir released approximately one million cubic meters of toxic red sludge, flooding several nearby villages. The sludge in itself was a hazardous mixture of water and mining waste containing heavy metals. This event is considered to be one of the major environmental disasters in the last 30 years. [28]

The main consequences of this disaster were: [29]

1. 10 people were killed and 150 suffered toxic burns;
2. 350 houses were destroyed and a total of 1,000 hectares were contaminated;
3. Local agriculture was impacted by long-term contamination of farmland;
4. Contamination of Hungary's waterways, even reaching the Danube. High alkaline levels killed all fish and caused severe damages to local ecosystems. Environmental experts stated that high alkaline concentrations in water are an irritant but not life-threatening for people.

An engineering report aiming to identify the failures in the stability of the dam, concluded it resulted from:[30]

1. The plant was located in an area sensitive to weather conditions.
2. Significant difference in the height and rigidity of the western and northern embankments causing an unfavourable connection at the corner of the reservoir.
3. The underlying geotechnical conditions where the corner of the reservoir was located.
4. The increase of load on the slope surface of the embankment.
5. The liquefaction property and special thixotropic behaviour of the "red mud".
6. The extremely unfavourable wind direction and wind speed conditions during that time period.

The Hungarian government spent more than $US166 million on accident recovery, with around US$51 million of that sum dedicated to clean-up activities. The high recovery costs and the human and environmental exposure led the Hungarian Parliament to nationalize the company.

Drawing lessons from the disaster, **it is important to share knowledge on how to prevent similar environmental disasters, to identify and assess the potential operational risks and to improve Crisis Management** from the acute phase all through long-term aftercare in order to minimize consequential losses in the aftermath of such a disaster. In order to minimize economic losses and alleviate environmental impacts of disasters, additional programs on environmental emergency preparedness should be developed and aligned with the Rio +20 commitment to "reduce human suffering and economic losses from industrial accidents." **An insurer can assist in developing such programs.**

Hungary, 2011

5.3 Pollution from Modern Agriculture

In modern agriculture, factory farming and intensive cultivation of fields importantly contribute to pollution of the ground and land surfaces. Agricultural pollution results from diverse sources such as soil erosion, fertilizers, pesticides and animal waste – mainly pig manure.

Liquid manure or ammonium phosphate used for soil fertilisation are often spread on fields in excessive amounts. Being highly soluble, nitrates spread over the land or produced in situ by some crops (e.g. fodder rape) can be leached by rainfall. They enter surface water or groundwater, where oxygen-reducing processes are triggered. Nitrate concentrations have been steadily increasing in rivers and groundwater for 40 years, at times exceeding the limit for drinkability. An additional increase in the concentration of ammonium, which also transforms into nitrates, accentuates the issue. A reduction in nitrate concentration can then only be expected through the effects of dilution in groundwater or by denitrifying bacterial processes.

People can absorb the nitrates via groundwater and drinking water. In the body, nitrates are converted into nitrites, which may affect oxygen transport (methemoglobinemia) and are often leading to cyanosis in infants. In addition, nitrosamines, which are carcinogenic, can form from nitrite and protein.

Water bodies with high nitrates concentrations are additionally subject to eutrophication with important environmental impacts (see Nitrates and Blue-green algae example on page 21).

Many mineral fertilisers also contain phosphate fertilisers, which have a natural content of uranium and cadmium. These pollutants can accumulate in the ground and be transferred to rivers through soil erosion. They can also be transferred to groundwater through leaching. Excessive exposition to fertilisers can generate kidney failure, hypertension and skin diseases.

Pesticides (herbicides, insecticides and fungicides) are used by farmers for pest control purposes, and can have harmful effects, particularly if they are transferred to groundwater or surface water. Surveys suggest that for about 10% of waterworks in Germany, levels of pesticides are too elevated in untreated water. Expensive cleaning measures are required as a consequence.

DANGEROUS PESTICIDES IN WATER BODIES

Amongst current pesticides found in quantities in water bodies, some are beginning to raise concerns and may be banned in the years to come:

- Nicotinoids are accused of killing pollinating insects, including bees;
- Glyphosate, most commonly known as Roundup, is suspected to be carcinogenic;
- Chloredecon is largely used in French Antilles for cultivating bananas with severe health consequences and little hope for a clean-up.

In livestock farming, various antibiotics and anti-parasitic agents are used against infections from bacteria, protozoa and parasites. A large portion of the active substances (between 60% and 80%) is excreted by the animals in a form that is still biologically active. These pharmaceutical agents can be released into the environment through the spreading of sewage sludge, or as a component in farm manure, or via pasture grazing. Transferred to natural water, they participate in the development of antimicrobial resistance (see box Antimicrobials in wastewater on page 27).

In addition, water may be polluted not only by chemical substances but also by micro-organisms. For example, *Cryptosporidium Parvum*, a unicellular parasite that water filtration systems sometimes fail to capture, exist in livestock and can cause infectious diseases in humans if ingested. Thus, agricultural businesses could also be considered to be a potential source of epidemics.

NITRATES AND BLUE-GREEN ALGAE

An example of water pollution caused by the extensive use of nitrate fertilizers in agriculture is the development of blue-green algae. Although they exist naturally, they grow particularly rapidly in nitrate-rich environments, causing a "blooming" phenomenon that has often made the headlines when it infested popular beaches in Brittany, France, at peak holiday times.

Blue-green Algae in Florida

More recently, Florida had to declare a state of emergency twice in the first half of 2016, as toxic blue-green algae were blooming[31].

The Florida Department of Health said that at high levels, this type of algae can "affect the gastrointestinal tract, liver, nervous system, and skin" and encouraged people to avoid contact with the bloom, adding that "children […] were especially vulnerable".

People can become exposed to blue-green algae, also called cyanobacteria, by drinking or bathing in contaminated water, or through consumption of contaminated fish. Diseases it can cause vary according to the type of toxins and exposure, but symptoms include skin irritation, stomach cramps, vomiting, nausea, diarrhoea, fever, sore throat, headache, muscle and joint pain, blisters of the mouth and liver damage. Blue-green algae's toxicity also develops with the decaying process that starts within 24 hours of the algae beaching, which leads to the release of very toxic hydrogen sulphide gas.

The toxic algae can also have an impact on biodiversity as it deprives marine life in its environment from oxygen. It can also have an impact on the economy, as was the case in Florida where business were affected and where beaches along Florida's Treasure Coast were closed on the 4th July weekend in response to the expansion of the green sludge.

In the European Union

In April 2016, Germany was referred to the Court of Justice of the European Union for not taking appropriate measures to limit the phenomenon.[32] Prior to that, in 2014, France was condemned for the second time by the EU Court of Justice (first time in 2012) for the same motive. Grounds for litigation is non-compliance with the EU Directive on Nitrates[33] which aims at protecting water quality by preventing nitrates from agricultural sources polluting ground and surface water. It encompasses implementation measures such as the identification and designation of "Nitrate Vulnerable Zones".

In France, out of 35,000 water catchments, 8.5 % were above authorized thresholds, with either a nitrate concentration above 50 milligrams per litre or a pesticide concentration above 0.5 micrograms per litre. From the early 2000's, France had to close 2,000 catchments that were too polluted to continue to be exploited.

However, it should be noted that cyanobacteria pollutions are only transitory. One should distinguish these blue-green algae (cyanobacteria) from the much more frequent green algae that are non-toxic and even comestible. Nonetheless, real nuisance is caused by these green algae, which accumulate massively on beaches with potential significant economic and ecological consequences.

5.4 Pollution from Urban Areas

Domestic wastewater from private household and residential use essentially carries organic pollution. Insufficiently treated water discharged into rivers cause important degradation of the environmental quality downstream. Urban pollution increases the concentration of ammonia, which is toxic to fishes and transforms into nitrates, and of phosphates from detergents and domestic waste. Domestic wastewater is also rich in heavy metals (see Flint example on page 23), organic micro-pollutants, and residues from medicinal products shed in urine and faeces.

Groundwater in urban areas sometimes contains multiple contaminants at higher concentrations than in rural areas. They migrate to the groundwater table together with rainwater infiltration. Leaking sewage, household discharge, rusty tanks, hospital effluents, industrial spillages, landfill leachates (liquids that drain from waste disposal areas) and fertilisers used in gardens and parks are common sources of nitrate, heavy metals, fluoride, arsenic and volatile organic carbons in urban areas. Several kinds of pharmaceuticals and perfluorinated surfactants (PFSs) can also be found in urban groundwater.

The result of this situation is that groundwater in cities is usually unsuitable for drinking or bathing because of contamination. In China, for example, according to the Ministry of Water Resources (MWR) more than 80% of the groundwater is contaminated and necessitates some legal restriction on use.[34]

Storm Waters and Floods

Considerable pollution flows into rivers due to storm waters and floods.

In cities, runoff waters collect dust, waste and hydrocarbons from vehicles. Sewer overflows transport untreated domestic pollution directly into the natural environment. Floods in agricultural fields or industrial areas result in water containing chemicals and solid particles.

Such pollution, brief but severe, leads to environmental damage, including fish mortality, and necessitates expensive clean-up costs. Floods can also be responsible for soil contamination of agricultural lands, with subsequent threats to food quality.

5.5 The Role of Re/insurance

Liability arising from damage to the environmental segment of water, soil and air are addressed by re/insurers under their Environmental Impairment Liability (EIL) and General Liability (GL) covers. EIL insurance as part of a company's enterprise risk management goes some way in demonstrating a company's social responsibility and can generate public confidence as well as help manage crises.

Re/insurance companies should further develop risk management strategies and risk assessments of the insured industries, cities and agriculture. Special underwriting knowledge could be built up in the field of risk evaluation of contaminated sites and risk-avoiding strategies.

Insurance can facilitate risk assessment and the introduction of loss-prevention strategies. The role of insurers is to be a professional partner to the insured in evaluating EIL-related risks and developing appropriate insurance and other risk management policies. For example, insurers may help determine the risks and potential exposures through client interviews, and inspections. They may also provide training in these areas.

FLINT: TOXIC TAP WATER, USA

Background

Flint, Michigan located 70 miles north of Detroit once thrived as the home of the US's largest General Motors plant. In 1967, Flint switched its fresh drinking water source to one of the Great Lakes, which is amongst the largest sources of fresh water in the world. The prior water source, the Flint River, was severely degraded from years of industrial waste and the presence of toxic substances. Despite this background, state officials, in an effort to cut costs, made a decision to switch the city's water supply back to the Flint River in April 2014.

The Flint River was still heavily contaminated with chloride, a chemical corrosive to the lead water pipes used to distribute water in many US cities, including Flint. Since the water wasn't properly treated, lead from aging service lines to homes began leaching into tap water.

After a prolonged series of denials, in January 2016, the state Governor finally conceded that Flint's contaminated water supply constituted a serious public health issue and declared a state of emergency. State and county police, the local National Guard, and the American Red Cross were deployed to distribute bottled water, water-testing kits and filters.

Outcomes

The fall-out from the crisis has been extensive. Multiple class-action law suits have been filed against the State Governor, the State of Michigan, the City of Flint, as well as numerous state agencies and officials. Several state and local officials have been criminally charged. If convicted, the individuals involved could face up to five years in prison. A French water company and a Texas firm have been sued for professional negligence and fraud for continuing to allow the lead poisoning to worsen.

Insurance Implications

The Flint crisis illustrates how the mishandling of water's status as an essential commodity can cause diverse and widespread damage. **Coverages for property, both residential and commercial, could face coverage restrictions, limitations on damages and price hikes. D&O and professional coverages for officials of suppliers who worked on the Flint crisis could also face restrictions and price hikes.**

Although the water supply switch decision is costing Flint far more than any planned savings, within the insurance sector, coverages in other municipalities with aging infrastructure could be affected both in terms of availability and pricing. Meanwhile the damages to Flint's finances and liveability continue to unfold:

- Rising public health costs from lead poisoning;
- Pipe network repair costs of up to US$1.5 billion;
- Lost tax revenues;
- Property value falls and spikes in vacancy rates;
- City flight by younger affluent residents.

6 WATER & HEALTH

- Low water quality continues to be a major source of global morbidity and mortality.
- Water-related diseases as well as contamination significantly impact human health.
- Global trends, such as climate change, are expected to intensify the problem by increasing the prevalence of water-borne diseases, so the related morbidity and mortality rates are likely to rise further.
- **For re/insurers, these trends pose both opportunities and threats, e.g. higher demand for product and environmental liability insurance.**

6.1 General Considerations

In the 21st century poor water quality continues to pose major threats to human health. Despite significant improvements and the achievements of the United Nations Millennium Development Goals[iii] on drinking water, safe and readily available water is not a given for many people[35].

Some facts and figures published by the World Health Organisation (WHO)[36] highlight water-related health issues:

- Globally, at least 1.8 billion people use drinking-water sources contaminated with faeces.
- Diarrheal disease caused by unsafe water and by lack of sanitation and hygiene is responsible for the death of 1.5 to 2 million people every year, mostly children under five.
- Water treatment could prevent about 438,000 annual deaths from malaria.

6.2 Water-Related Diseases

Next to malaria there are other well-known bacterial and viral diseases that have their roots in unsafe water and insufficient sanitation conditions.

Cholera and typhoid fever are relevant bacterial diseases in the context of water risks, both with significant mortality outcomes. The bacterial agents that cause both diseases are transmitted by human faeces and spread mostly by contaminated water and food.

Cholera manifests itself in periodic and regional outbreaks (e. g. Zimbabwe 2008, Haiti 2010, Sierra Leone 2012) and is worsened by the lack of suitable care.

For typhoid fever, the impact is more distributed over time, and the risk of the disease persisting in a community is high. Due to the large number of recovered but still infectious individuals, the number of affected patients is around 30 million per year.

A common viral disease linked to poor sanitary conditions and hygienic practices is hepatitis A. It usually spreads by eating food or drinking water contaminated with infected faeces. In developing countries, around 90% of children are infected with the hepatitis A virus before the age of ten.

[iii] The Millennium Development Goals (MDG) were 8 international development goals for the year 2015, established following the Millennium Summit of the United Nations in 2000. Each goal had specific targets and dates for achieving these targets. The Sustainable Development Goals (SDGs) replaced the MDGs in 2016.

Mosquito-Transmitted Diseases

Several high-profile diseases are closely linked to water as the breeding ground for mosquitoes.

Classical examples are malaria and dengue, with yellow fever and zika gaining more attention recently. Malaria is a tropical disease caused by a single-celled parasite (*Plasmodium spp.*), transmitted by the *Anopheles* mosquito. According to the WHO "World Malaria Report 2015"[37] the number of people affected by malaria is about 214 million. There are 438,000 fatalities each year from malaria, 70% of which are children under 5 years of age. Currently there is no vaccination available, despite long term research in this field. Symptoms of malaria are periodic high fever, shivering, gastrointestinal complaints and convulsions.

Dengue fever, yellow-fever and the zika virus are spread by another mosquito, *Aedes aegypti*. Dengue is common in more than 110 countries. Up to 500 million people are estimated to get infected per year, with a death toll of approximately 10,000 to 20,000. With yellow fever, the emerging risk lies in the potential spread of the underlying flavirus from Africa, where it is already endemic, to Asia, where it is currently not locally transmitted but where the environmental conditions are favourable and could lead to an imported epidemic.

Currently the strategy to mitigate the burden of these infectious diseases is based on four main pillars:

- Sleeping in insecticide-treated mosquito nets;
- Use of indoor residual spraying;
- Intermittent preventive treatment in infants and in pregnancy;
- Larval control.

Mosquitos have to go through four life cycle stages. The first three stages are water dependent (aquatic) and last up to two weeks. The mosquito larvae can live in all bodies of standing water. Larval control is used in several countries globally. Such control involves vector habitat modification or manipulation, larviciding and biological control, e.g. use of fish as larval predators or genetically modified mosquitoes. So far it is difficult to quantify the impact of these different interventions.

Transmission of these tropical diseases is temperature sensitive, therefore the long-term efforts to fight against them will also be influenced by global climate change. Contributing factors in transmission dynamics are urbanisation, population growth and deforestation. A WHO prognosis assumes that we will see an increase in malaria burden in those regions that are endemic for malaria, particularly in densely-populated tropical highlands.

Close up of the Anopheles mosquito which uses shallow waters as favourable breeding sites.
In New Delhi, India, health workers had to spray pesticide on pools of stagnant rain water in the fight against malaria.[38]

With climate change, such diseases are expected to spread geographically impacting healthcare costs, morbidity and mortality. For re/insurers, the risk of pandemics represent potentially substantial risks of unexpected accumulation.

6.3 Influence of Climate Change and Weather Events on Water-Related Diseases

Climate change and shifts in ecological conditions, such as changes in temperature, precipitation patterns and extreme weather events, will promote the spread of pathogens, parasites, and diseases (see Mosquito-transmitted diseases example on page 25). However, the spread of infectious diseases also depends on non-climate factors: socio-demographic influences, drug resistance and nutrition, as well as environmental influences (such as deforestation, agricultural development, water projects), urbanisation, global development and land use change. In fact, the impact of climate change on health is likely to be dependent on how effective humans are at coping with or countering the effects of diseases.

Flooding and heavy rainfall sometimes cause overflows from sewage treatment plants into fresh water sources or agricultural plots, which may contaminate drinking water or food crops with pathogen-containing faeces. In addition, it will also increase the number and prevalence of waterborne parasites found in drinking water. These parasites cause gastrointestinal distress (e.g. gastroenteritis and/or diarrhoea) and, in severe cases, death.

Some diseases that affect aquatic life become more prevalent in warmer waters. As an example, the marine white spot disease caused by the parasite *Cryptocaryon* is a significant problem for marine aquarists and commercial aquaculture worldwide. The disease is known to infect many different fish species, although there appears to be a difference in susceptibility. In particular, shrimps in aquacultures seem to be at high risk. Once the organism gets into a large aquaculture facility, it is difficult to control due to its fast reproductive cycle and its unique life stages. If not controlled, there is a 100% mortality rate of the fishes. The optimal growth temperature range of most strains of *Cryptocaryon* appear to be about 23 to 30°C. Higher sea water temperatures may therefore promote the spreading of *Cryptocaryon* strains.

The spread of climate-sensitive diseases will depend on both climate and non-climate factors. Industrialized countries provide public health infrastructure and programs to monitor, manage, and prevent the spread of many diseases. The burden of climate-sensitive diseases is much higher in poorer countries with inferior capability to prevent and treat illnesses.

6.4 Water Contamination

In addition to contamination from pathogenic organisms, water is a vector for other health-threatening substances, such as chemicals, artificial compounds or heavy metals. For some of them, called Endocrine Disrupting Compounds/Chemicals (EDC), there is strong evidence of interference with human hormonal systems (see the 2012 CRO Forum Emerging Risk Initiative Position Paper on Endocrine Disruptors).[39]

Another example is the case of arsenic contamination of groundwater. Arsenic is a typical contaminant, naturally present in the aquifer rocks and slowly dissolved by water. Its ingestion has severe health effects, for instance on bones and skin, which can be both chronic and acute. It can be found in more than 70 countries worldwide including the US and affects millions of people in Bangladesh, Vietnam and some other Asian countries where rural populations often rely on groundwater from wells. In Bangladesh, switching from surface water contaminated with microbes to groundwater reduced infant mortality from water-related infectious diseases, but exposes the population to arsenic. The contamination can be removed from the water by treatment, but this is usually too costly for the rural population.

In other countries, e.g. India, fluoride may be a similar problem.

Failing or inadequate water pipe infrastructure can contribute to negative health impacts, e.g. by raising the levels of toxic elements such as lead in tap water (see Flint Water crisis example on page 23).

ANTIMICROBIALS IN WASTEWATER[40]

The consumption, misuse and overuse of antimicrobial agents is common in both human and veterinary medicine, with the consequence that microorganisms are becoming increasingly resistant to them. They enter water in effluent from industries, agricultural waste or municipal sewage, and threaten human health:

- Through ingestion as chemical contaminants in drinking water
- By making microorganisms in water or in the environment more antimicrobial-resistant

The WHO assesses Antimicrobial Resistance as a "major threat to human health", with expected increases in healthcare costs, morbidity and mortality. This is also a major Emerging Risk for re/insurers.

6.5 Prevention Strategies

A substantial number of diarrheal disease cases and other water-related health conditions could be prevented by access to safe water, adequate sanitation facilities and improved hygiene practices, in particular in developing countries. Regular access to good sanitation is a potent approach in preventing drinking water from becoming contaminated with human excrement and reducing infection rates.

Most of the measures recommended by the WHO to improve water quality are comparatively cheap and easy to achieve, but are often thwarted by political and social circumstances. Beneficial effects are not only health related, but there are economic benefits as well, such as reduced health care costs, access to education for children and improved labour productivity.

Vaccination is another successful measure against infectious waterborne diseases. For polio, a faecal-oral transmitted viral disease, thus communicable through contaminated water, vaccination measures turned out to be a success. Apart from a few war-torn states the world is now polio-free. However, for most of the waterborne infections there are no such effective vaccinations available. For cholera and typhoid fever, available vaccinations are less effective (max. 60-80%) and protection wanes within a few years. In these cases, an approach via a clean water policy is much more appropriate and reliable.

6.6 Impacts on Re/Insurance Industry

Many waterborne and water-related diseases affect human health. Although some progress has been made in their containment, new dynamics from climate change may eradicate previous successes. If diseases migrate from endemic regions to previously disease-free areas, people there are much more susceptible to infection and transmission of these diseases. It is therefore likely that both morbidity and mortality will increase. Insurers have to take these developments into consideration for product design and premium calculation.

Responsibility of industries involved in water pollution is already day-to-day business in developed countries. It can be foreseen that with increasing water stress the rules and regulations will become tighter, and as a consequence liability issues will be more significant in the future. The most affected lines of business will be product liability and environmental liability.

For livestock farmers there is an increasing demand for business interruption insurance and price protection insurance to safeguard them from the side effects of outbreaks of diseases. Insurers will have to understand the dynamics of the underlying risk in order that product design and pricing are correctly adapted.

7 Water Treatment & Disposal / Removal / Recycling

- Water treatment is essential to improve the supply of fresh water.
- However, the process is highly energy intensive and costly, which can be a problem in developing economies lacking investing capacities.
- Furthermore treatment plants, which carry out the physical processing, are vulnerable to operational failure and can become targets for sabotage or terrorism.
- Innovative technologies are being developed to bring greater efficiency in treatment systems. Trends of water reuse and recycling also appear to help secure water requirements.
- **Insurance solutions that can ameliorate some of the risks include business interruption coverages and environmental liability insurance**.

7.1 Importance of Water Treatment

Treatment of water and wastewater is both a priority and a challenge. Adopted by the United Nations in September 2015, the sixth Sustainable Development Goal (SDG) aims to "ensure availability and sustainable management of water and sanitation for all" and comprises technical targets relating to drinking water, sanitation, hygiene and wastewater management, amongst others. Water treatment is key to reaching these targets: raw water may contain substances such as suspended solids, micro-particles, pharmaceuticals, trace chemicals, natural and synthetic hormones, bacteria, algae, viruses, fungi, minerals and toxic substances. If they are not removed during the water purification process, their presence in drinking water may lead to waterborne diseases and health issues. Even in the case of wastewater effluent, which is usually not reused and disposed in water streams, treatment contributes to limiting environmental risks related to pollution.

Water treatment is costly and energy intensive. As a result, the availability of water treatment is often correlated with economic prosperity[41]. A comparison of different countries shows that those with a high GDP per capita spend more money on water treatment than less prosperous countries (see Figure 3). Lack of treatment is an issue in many emerging countries[42].

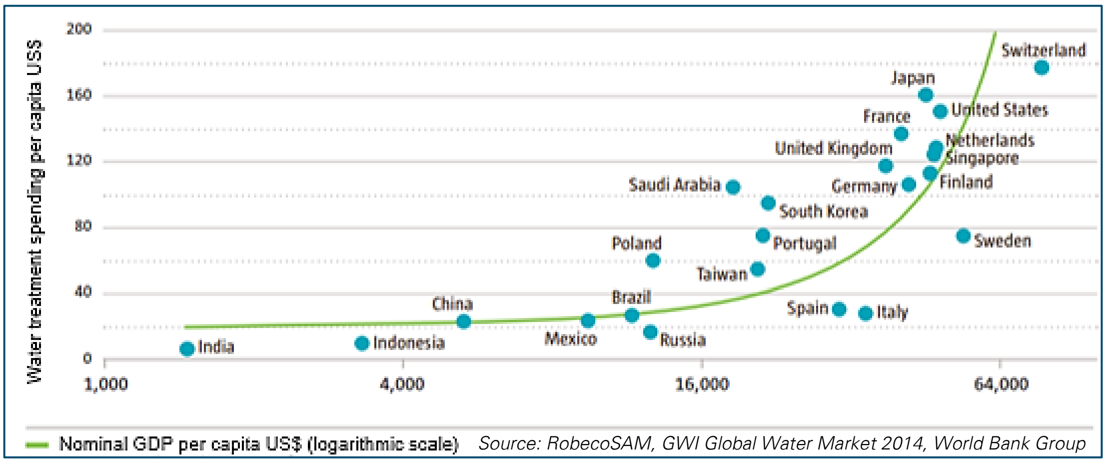
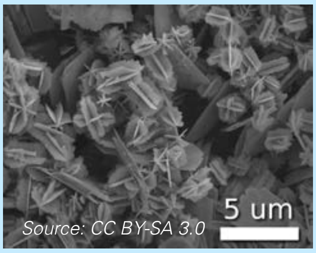


Figure 3 Water treatment spending is correlated with GDP per capita.

Note: Water spending and GDP per capita data period are from 2010, 2011, 2012.

Nanoparticles / Micro-particles in Water



"Nanotechnology is an emerging and promising field for advanced applications in industrial, commercial and medical sectors, and nanomaterials can be found today in sunscreens, deodorants and textiles. Yet these nanomaterials, which are increasing in number, are entering waste streams as part of end-of-life products along with conventional waste, without any real understanding of their environmental impacts or health risks on human beings and living organisms". [43]

Nanostars of Vanadium oxides [44]

In its recent report, the OECD highlights the significant knowledge gaps that remain on nanotechnologies' indirect health and environmental impacts through waste streams (e.g. presence in fresh water). It analyses how state-of-the-art wastewater treatment facilities may collect, divert or eliminate nanomaterials from waste streams. Among the knowledge gaps that are pointed out in the conclusion, understanding of the impact of spreading sludge issued from waste water treatment as fertiliser on agricultural lands is still limited.

Nanoparticles might be released into the environment where they can accumulate for long periods of time. While their ecotoxicity on aquatic organisms for example requires further assessment, a study on the environmental concentration in Europe, the USA and Switzerland showed that nanosilver, nano-titanium dioxide and nano zero-valent iron (used in permeable reactive barriers for groundwater treatment) posed marked ecotoxicity risks in sewage treatment plant effluents.[45]

On the other hand, recently developing applications are nanoengineered water technologies, which represent potential for significant innovations in water treatment in the coming decades. They offer potential for treatment of surface water, wastewater or contaminated sites. The types of nanoengineered water technologies and corresponding properties can be broken down as follows:

Nanomaterials	Properties	Applications for water treatment
Nanoadsorbents (e.g.: carbon nanotubes)	+ high specific surface, higher adsorption rates, small footprint – high production costs	Point-of-use devices, removal of organics, heavy metals and bacteria
Nanometals and nanometal oxides (e.g.: nanosilver, nano-titanium dioxide, nano zero-valent iron)	+ short intraparticle diffusion distance, compressible, abrasion-resistant, magnetic + photocatalytic (nano-titanium dioxide) – less reusable	Removal of heavy metals (arsenic) and radionuclides
Membranes and membrane processes	+ reliable, largely automated process – relative high energy demand	All fields of water and waste–water treatment processes

Source: National Institutes of Health – National Center for Biotechnology Information (NIH-NCBI)

Note: A nanoadsorbent is a substance which has the ability to attract other materials or particles by surface adhesion.

Although promising, the development of nanotechnologies in water treatment is subject to some technical limitations: for now, nanoengineered water technologies are rarely adaptable to mass processes, thus at present, in many cases they are not competitive with conventional treatment. However, they can be integrated into existing conventional modules, or be useful for decentralized treatment systems and point-of-use devices.

Nanotechnologies hold tremendous opportunities for a wide range of applications. Yet they present the re/insurance industry with significant challenges, due to the uncertainty around environmental, health and safety exposures. This has a direct impact on the potential effectiveness of risk management, the availability of insurance risk transfer product and the ability of insurers to establish suitable reserving practices (see the 2010 CRO Forum Emerging Risk Initiative Position Paper on Nanotechnology).[46]

7.2 What Is Meant by "Water Treatment"

Water treatment encompasses any method of cleaning water for a specific purpose. Water treatment techniques and water quality requirements depend on the use that is being made of the water or on the initial source of pollution. For domestic use, drinking water requires the most extensive treatment, but not all water treatments aim to achieve drinking water standards. Treatments may occur at different stages of the water cycle, before and after use. Different physical, chemical and biological processes exist to ensure the removal of contaminants or the reduction of their concentration.

Disposal of urban wastewater represents specific challenges in view of rapid urbanisation and demographic growth, which make adequate water treatment critical. Many households in urban areas are not connected to a proper sewerage system. Connecting all users to the water treatment system is a challenge but also offers opportunities in terms of developing water services.

Water for agriculture (i.e. irrigation) generally receives little or no treatment nowadays, although polluted irrigation water can pose health risks.[47]

Water, as a nearly universal and inexpensive solvent, is used in many industrial processes for its capacity for absorbing, diluting and transporting waste and pollutants. Industrial effluents are often poorly treated and released without adequate treatment. In developing countries, an estimated 70% of industrial waste is discharged without treatment into usable water supplies. Oil and gas extraction yields high volumes of "produced water", which comes out of the well along with the oil and gas. Produced water is usually very difficult and expensive to treat.

Water treatment processes have considerable energy requirements.[48] The amount of energy needed in water and wastewater treatment processes varies greatly and is dependent upon factors such as the quality of the source water, the nature of any contamination, and the types of treatment. Extensive water treatments are very costly and even with very stringent standards, some substances are in concentration sufficiently low to be left untreated. Their effect on the environment and on human health is still unknown and might be underestimated (see Nanoparticles example on page 29).

7.3 Treatment Plants Are "Critical Infrastructure" and Need to Be Secured

Treatment of water and wastewater generally takes place in big centralized plants connected to water supply systems. They are often considered as Critical Infrastructure with high security risks. The market for water treatment, distribution plant and equipment for domestic and industrial use was valued at US$557 billion in 2013.

Hazardous substances may be introduced during the process of treatment, or hazardous circumstances may allow contaminants to pass through treatment in significant concentrations. A failing treatment or pollutants introduced by terrorists at water treatment plants would spread quickly and widely through the water network system, with potentially huge impacts such as illnesses, deaths, economic life disruptions and mass panics for cities and industries. In particular Nuclear, Biological, Chemical and Radiological (NBCR)-related contaminants spread in water from natural disasters, accidents or malevolent attacks would represent a major threat on water networks. Water centres thus require close monitoring of water quality, even more during major public events.

Owners of water treatment plants hold responsibility for the continuity of service and the quality of water going in the network or back to the environment. The operating model and ownership structure of water utilities varies across regions. In most countries, public authorities or state-owned organizations are responsible for the supply of drinking water and wastewater treatment while in some countries, these services have been privatized or organized as public-private partnership. Globally, about 14% of the world's population is served by private operators, with an expected rise to 21% by 2025. The strongest growth in private sector participation will likely come from emerging market countries.

Desalination Projects

Barcelona is faced with an increasing population and a water storage capacity close to yearly demand. Since 1982, drought alerts have become a frequent phenomenon in the metropolitan area, and occurring as often as every 2 to 3 years since the beginning of the year 2000.[49]

In response to an acute water shortage following the dry seasons in 2008, the public entities Sociedad General Aguas de Barcelona (AGBAR) and Aigua Ter-Llobregat (ATLL), responsible for safeguarding the water-supply in the Barcelona area, took some significant measures by building Europe's largest desalination plant. The El Prat desalination plant started its operation in 2009 and supplies 24% of the water consumed in the Barcelona metropolitan area. This amounts to providing 200 million litres of drinking water daily to the region's 4.5 million inhabitants, thereby converting 100 litres of salt water into 45 litres of drinkable water.[50]

But Barcelona is not alone in having recourse to such an innovative alternative for ensuring water safety. Across the globe, the output of desalination plants has increased tremendously. While hardly any desalination infrastructure existed in the early 1970s, output reached 86.8 million cubic meters per day by June 2015. More than 18,000 plants are in operation today.[51] Many of these plants are supplying regions facing severe water shortages, such as the Middle East, Southern Europe or Australia. Overall, more than 300 million people rely on desalinated water worldwide today and its dependence is expected to grow. Given the upcoming water scarcity, desalination could be the next boom.[52]

The main engine of a desalination plant is the Reverse Osmosis (RO) membrane. These membranes remove the salt and other materials from the water molecules in a process called reverse osmosis, where seawater is pressurized against the surface of the membrane, causing transport of salt-depleted water across the membrane and emergence of drinkable water from the other side.[53]

An increase in membrane efficiency, i.e. in the amount of drinkable water that can be produced by one membrane element, and technological innovation in energy recovery equipment in the early 1990s, allowed filtration costs to decline substantially, thereby causing a rapid growth in water desalination across the globe.[54] Thus, with the beginning of the new millennium, water desalination became a viable and widespread alternative to traditional means of water generation and its usage is expected to grow.

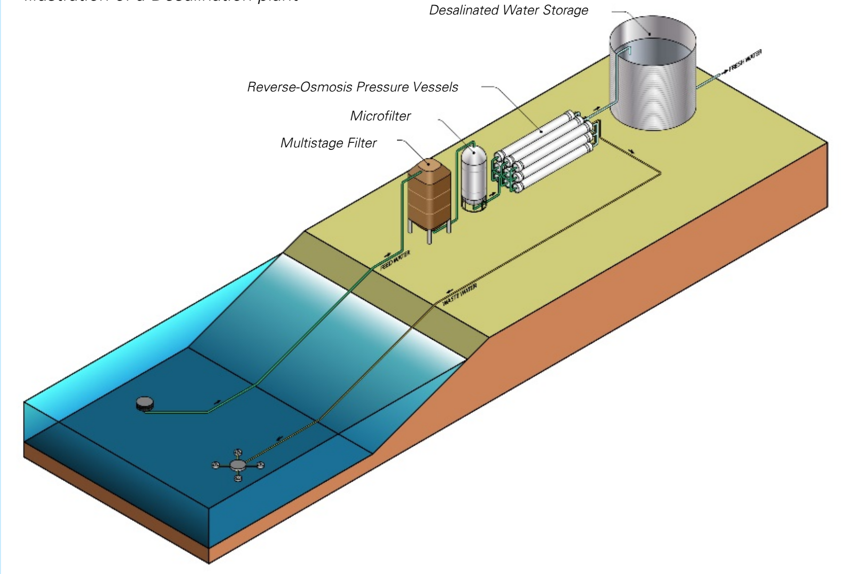


Illustration of a Desalination plant

In Europe, London also constructed desalination plants and other cities are considering it.

Infrastructures such as desalination plants require tailored insurance programs to address their specific needs. Challenges come from their important size, use of advanced costly technologies (some time being prototypes), usual proximity to large population centres and vulnerability to natural catastrophes.[55]

7.4 New technologies and Innovations

As the need for water treatment is growing, new technologies are being developed. Desalination is an emerging process increasingly used. It is more energy intensive than traditional water treatments and, because of its cost, is only adapted for dry regions. Large projects are developing in the Middle East, in the US, Australia and Europe (see Desalination example on page 31). Other alternatives aim at reducing the environmental impact of water treatment. Anaerobic digestion is an option that could be implemented in many treatment plants to reduce sludge volume and disposal costs, produce a source of green energy (biogas), use organic material as a fertiliser and eliminate pathogens.

Recycling water may be particularly useful in agriculture: water recycling at all stages of the value chain can help secure water requirements. The risk is that reclaimed water for agriculture and park irrigation might be contaminated with pharmaceuticals and drugs that water treatments failed to eliminate. There is still no clear idea of the potential consequences of long term exposures.

Treating large quantities of reused water to make it drinkable again would require enormous amounts of energy: for that reason and for cultural ones – event treated, some people have trouble accepting the fact that they are drinking wastewater – it is still not acceptable at an industrial scale. Advanced technologies permit individual drinkable water reuse. Point-of-use water treatment systems, i.e. portable water purification devices, can cleanse drinking water at an affordable cost in individual homes or commercial establishments. Decentralized treatment systems offer an interesting alternative as they require less investment and simplify the access of households to wastewater treatments.

SMART MONITORING OF WATER RESOURCES

As water distribution systems and wastewater treatment plants expand in size and capacity, the need to closely monitor water networks is ever increasing. Innovative technologies are being implemented to improve such monitoring: smart control systems, increased automation, real-time data collection and analysis, network virtualization and control schemes.

Smart technologies help achieve better minimization of losses (through leakage reduction) and maximization of resource recovery (supervision of water quality and quantity). However, there are also issues to this approach such as cybersecurity, or instrumentation and data quality.

7.5 Impacts on Re/Insurance Industry

Water treatment is associated with many risks, which must be assessed and taken into account, but it also brings opportunities for insurers and reinsurers.

As critical infrastructures, water treatment plants can be vulnerable to natural and man-made influences, and require risk assessments. Physical damage to a plant could have property and business interruption implications. In the US, more than 80% of the population receive their drinkable water from publicly owned wastewater purification systems, which the Department of Homeland Security says are "*vulnerable to a variety of attacks, including contamination with deadly agents; physical attacks, such as the release of toxic gaseous chemicals; and cyberattacks. The result of any variety of attack could be large numbers of illnesses or casualties and/or a denial of service that would also impact public health and economic vitality. The sector is also vulnerable to natural disasters.*"[56] For private operators, natural and man-made influences can have insurance implications. Environmental liability of water treatment plant operators can be at stake in case of undue contamination of water streams or watersheds, while liability for water treatment plant builders can be at stake if faulty engineering causes leakage of contaminated residues.

Water treatment business opportunities are linked to the emergence of stricter regulations and standards, and to the development of new technologies. The industrial sector is particularly affected (see Mining water treatment example on page 33). An associated risk is investing in new treatment technology that may become obsolete in only a few years.

MINING WATER TREATMENT

As a result of environmental regulations and high reputational pressure in the mining sector, mining companies seek to optimize their water management. **“Being a responsible water user is an opportunity for our company – it helps build stronger relationships with local communities and governments and enhances our social license to operate: being responsible makes it easier for us to do business”**

Anglo American, Global mining company operating in South Africa

Water is needed for the entire mining operation life cycle.[57] Environmental risks caused by the mining industry might include erosion, depletion of water supplies, reduction in biodiversity and contamination of soil, groundwater and surface water by chemicals from mining processes. Water run-off usually holds large concentrations of heavy metals, including mercury or arsenic. The cheapest solution is to build a pond to stock them, with the associated risk of major damage and enormous remediation cost in case of accident. The maximum possible insured property loss is often generated by a tailing dam failure or collapse.

Acid mine drainage refers to the outflows of highly acidic waters, rich in heavy metals, from areas where the earth has been disturbed, e.g. mines. It is one of mining’s most serious threats to water and can devastate rivers, streams and aquatic life for hundreds of years.

Water management in the Australian mining sector

Mary Kathleen mine, Australia[63]

Australia is the driest inhabited country[58]. In recent years average annual rainfall has decreased and parts of Australia have experienced drought conditions[59]. In 2014-2015 the mining sector in Australia contributed to 8.7% of the GDP[60] and export volumes were growing steadily due to China’s demand.[61] (Since China’s slowdown, Australian exports volume have dropped). While agriculture remains the major consumer of water, the mining sector uses 4% of national water resources.[62]

The 2004 Natural Water Initiative[64] and the 2007 Water Resources Act[65] represent policy efforts to provide a framework for a sustainable management and use of the water resources that sustain the physical, economic and social wellbeing of the people along with the ecosystems that depend on those resources.

Rio Tinto Argyle Diamond Mine, Western Australia

Argyle Diamond Mine is located in the remote north of Western Australia. Production began in 1983 and it is one of the world's largest supplier of diamonds[66]. The biggest user of water at the site is the processing plant, where water is needed to wash and separate the diamonds. Rio Tinto developed its global water strategy in 2005. Local water management activities consist of monitoring potential impacts on groundwater, engaging stakeholders and managing water use[67].

In 2005 the mine used more than 3,500 megalitres[68] of water from the Gap Dam, Jacko’s Dam and Lake Argyle. In 2013 the mine’s water consumption decreased to 464 megalitres[69] with 22.4% of recycled water. Lake Argyle is a recognised wetland site protected by the Ramsar Convention and its use is restricted to drinking water only. Rio Tinto has now developed a discharge target for the period 2014 to 2018 to reduce the downstream environmental impact of its operation.

Mining activities face multiple exposures, with a high potential for heavy losses in case of accident. Water risks related to mining are no exception. Working on risk mitigation with the insured (site visits, surveys and models to assess the risks) and ensure that premiums reflect the assumed risk is key for re/insurers.[70]

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8 WATER & GEOPOLITICAL / SOCIAL RISKS

- Water, as a key strategic resource that is unequally distributed across geographies, is a potent source of tensions within and between states.
- Tensions can stem from a number of causes including excessive withdrawals from water stocks or diversion of rivers for irrigation and hydro-electric projects.
- On top of inter-state conflicts and social unrest, water crises can also be responsible for large scale famines and widespread population displacement.
- While in recent years there has been a renewed international push to reduce tensions over competing claims on water, the potential for conflict remains high.
- **Re/insurers should be alive to these risks and take them into consideration when estimating their global reach.**

8.1 Sources of Water Conflicts

Water is one of the most critical resources for humanity, which creates a source of strategic conflict, from simple tension to crises affecting the population and to armed conflicts between nations.

The most contentious aspects of sharing water resources are development of infrastructures, water quantity and joint management (see Figure 4). Conflicts due to flood control schemes, which can lead to the displacement of population, and water quality issues (for instance unequal access to clean water) have increased in number since 2000.

Energy production with the help of dedicated infrastructures is still nowadays one of the main reasons for international water conflicts. Positive to societies in terms of supporting economic development and promoting energy security, hydropower can create problems in terms of reduced water volumes for populations downstream of the hydro-electric plants.

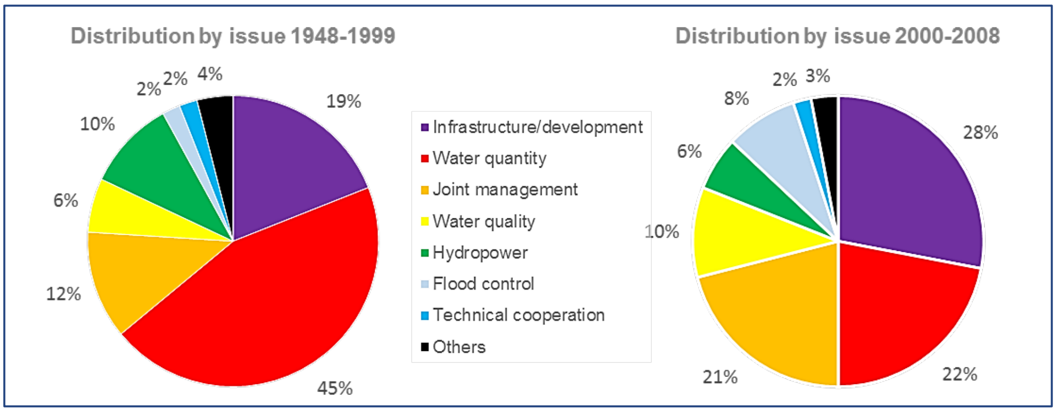


Figure 4 Distribution of conflicts by issue type.[71]

Note: Joint management refers to events that report generic interactions related to water management and that do not refer to any specific issues (e.g. creation of a joint committee for water management in general, expression of will to collaborate, celebration of meetings)

Besides these main topics, inefficient use, inequitable distribution, lack of control, law enforcement and sanctions can also cause critical developments in the field of water conflicts. It can reflect social problems: inevitably, the poor are more adversely affected by water management problems. This can lead to social unrest.

Three Gorges Dam Case Study, China

The Three Gorges Dam (TGD) is located in China's Hubei province. The dam stretches for more than 2 kilometres across the Yangtze River, which begins in the Tibetan highlands and flows to the East China Sea. It is the world's largest hydropower plant with an installed capacity of 22,500 megawatt. In 2014, the TGD generated 98.8 billion kilowatt-hours of electricity[72].

The project was approved in 1992 and completed in 2009[73] for a cost that ranged from US$25 billion to a high of US$60 billion[74]. The China Three Gorges Corporation (CTG), owned by the State-owned Assets Supervision and Administration Commission (SASAC), was responsible for the construction. Its subsidiary company, the China Yangtze Power, is the operator. It is one of the world's largest energy companies listed on the SSE 50 Index on the Shanghai Stock Exchange.

The project helped China to meet its growing energy needs to improve its record of greenhouse gases emissions, to increase the ability of flood control, to upgrade ship navigation, to reduce transport costs, to raise trade and to boost economic development in the region.

However, the TGD is not without problems. Geological hazards[75] consist in landslides (monitored and mitigated by concrete riverbank strengthening), in historical seismicity and in excessive sedimentation that could block the sluice gates and strand ships. Undesirable environmental impacts include biodiversity disruption and loss, increased intensity and severity of downstream droughts[76], surge in microbial waterborne diseases[77], weather changes (especially precipitation) and rise of pollution levels in the reservoir[78] due to sewage and industrial waste dumping. Up to 1.3 million people were relocated and an area of 1,000 square kilometres was submerged. Corruption scandals and extreme spring floods[79] have raised concerns amongst local population about the overall benefits brought by the TGD and its future.

All large water dams project have impact on population and environment. Authorities have to take this into consideration and to seek necessary re/insurance covers for the financial back-up of the projects.

Local expertise and insurance are largely available in China to deal with water dam projects. For the TGD, three domestic insurers underwrote a 10 billion yuan (US$1.2 billion) insurance for the construction.[80] From only a liability point of view in regards to the local contractors or as a warranty for new technological issues, reinsurance was not considered as a necessary vehicle for the completion of works. Nevertheless, other related risks such as the social and environmental impact of the construction need to be considered for this type of projects. Given the size of the investment, reinsurance (treaty and facultative) was still necessary to make sure that the local companies could manage balanced books, which could be compromised by peak risks.

The consequences of exceptional events (acts of God, dam rupture, and soil failure causing large material damage, floods or landslides) and affecting the surroundings would be covered by re/insurers when appropriate policies are in place. Also re/insurance companies can provide coverage to mitigate consequences of potential social unrest that would cause damage to the assets.

Three Gorges Dam on the Yangtze River, China[81]

Source: CC BY 2.0

Re/Insurance has once more a prime role as guaranty to the completion of the works, since for projects of this size, collateral risks add more complexity to the forecasted water-induced challenges.

8.2 Geopolitical Hotspots / Examples

Numerous conflicts have their roots in disputes over water resources. Northern Africa, the Middle East and Southern Asia are considered most exposed to these types of conflicts (see Figure 5 on page 37).[82]

One well-known and long-running water conflict has been over the river Jordan.[83] The region around Jordan has always been heavily reliant on the water supply of its main river, with several riparian countries (i.e. countries bordering a natural watercourse such as a river, a lake or a tidewater) competing for its water sources. In 1964, the Arab League consisting of Jordan, Syria and Lebanon agreed to divert a large part of the Jordan River headwaters away from Israel into the Yarmouk River. This led to further escalations the following year, with Israel conducting operations against the diversion project. Even today, access to the Jordan water remains an item of dispute[84], with resurgent disagreements on the appropriate amount of water usage of the Jordan River.[85] This competition over water resources is only one of many reasons for conflict in the Jordan region, yet it is a key feature during negotiations.

Similarly, the Nile basin contains vast potential for inter-state conflicts: 10 riparian countries share this river basin in one of the world's most arid regions. In particular, Egypt is the most downstream nation on the river basin and around 97% of its fresh water supply depends on the Nile River.[86] To alleviate potential conflicts over the Nile basin, riparian states launched in 1999 the Nile Basin Cooperative Framework Agreement, seeking to ensure an equitable utilization of its water resources. However, a Nile River cooperation agreement drafted in 2010 between up-stream nations revived the tension.[87] The dispute was settled in 2015 by a (secret) agreement between Egypt, Ethiopia and Sudan about the construction of the Renaissance dam.[88]

The Colorado River basin, the Danube or the Indus have also experienced inter-state conflicts and tensions related to water.

Next to inter-state conflict, social unrest is a common phenomenon in the case of extreme water shortages. Water crisis can lead to massive protests, especially in poorer districts (see São Paulo example on page 13).[89]

The construction of mega dams can lead to large scale involuntary migration. The largest projects completed so far were located in India and China, with the construction of the Three Gorges Dam at the Yangtze River leading to the displacement of up to 1.3 million people (see Three Gorges Dam example on page 35) or China's Danjiangkou Dam displacing 383 thousand people. According to estimates by the World Bank, over four million people globally suffer from involuntary displacements per year due to dam projects.[90] Estimates of overall displacements over the latter half of the twentieth century range between 30 and 80 million people.[91]

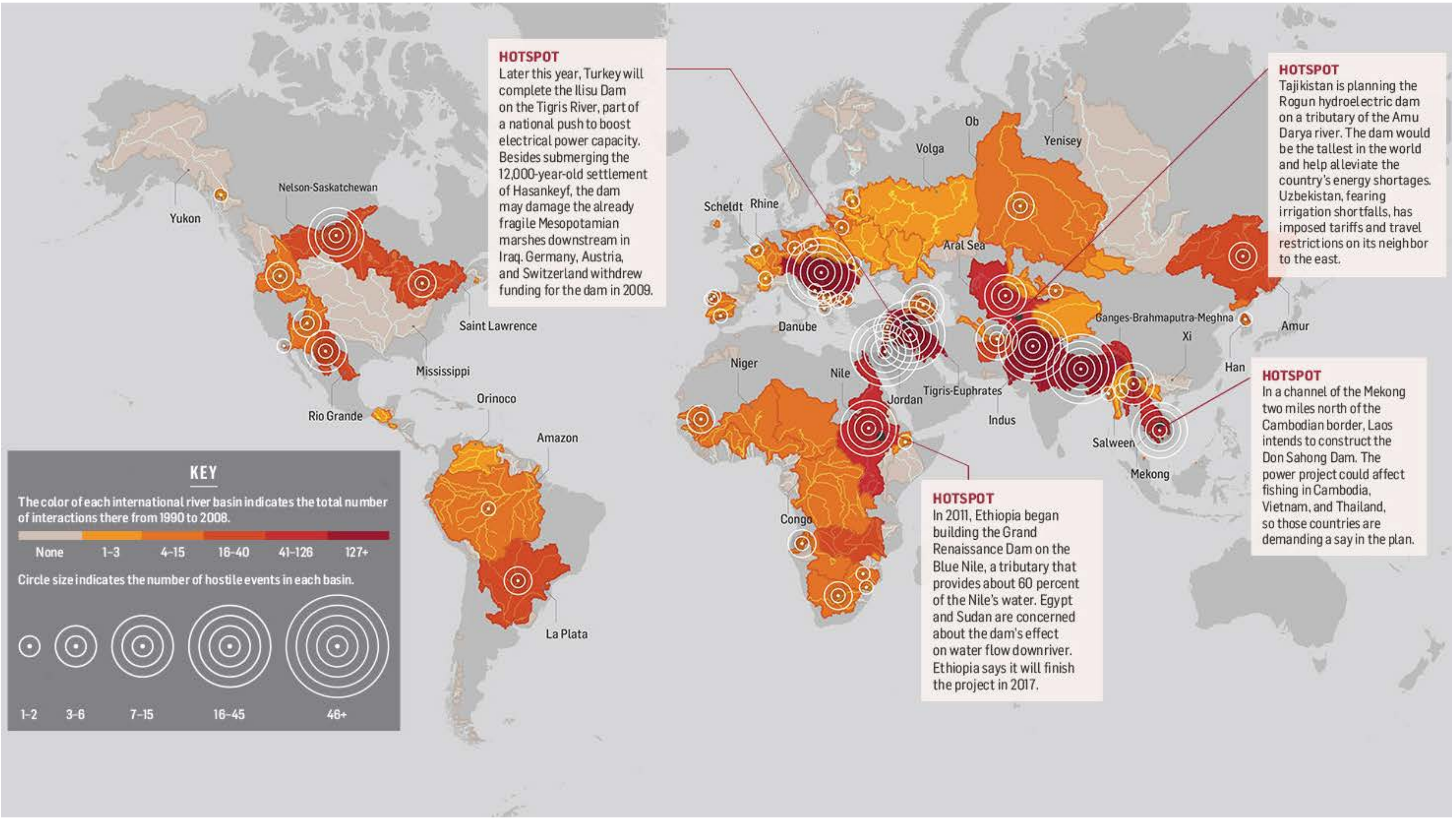
Water Crisis in Iran[92]

In Iran, climate change, economic development and strong growth of the population have led to a major water crisis. 97% of surface waters have already been used, resulting in dry river beds and lake disappearances. This impacts most of all agricultural activities. Industrial discharge into the remaining water bodies aggravates the problems arising from depletion, as river beds and lakes drying progressively concentrates the chemical elements and pollutants.

Since elections were held in 2013, environmental protection has become one of the main priorities of the government. As stated by the governmental advisor in charge of water, agriculture and environment, confronting the water crisis is now a prime necessity to stop Iran from becoming "uninhabitable" and being transformed into a "ghost country".

Figure 5 Heat Map: Where in the world will a water conflict erupt?

Source: Based on the Transboundary Freshwater Dispute Database (TFDD), International Freshwater Treaty Database



8.3 Famines and Environmental Migration

In effect, conflicts over water resources are even more about famines and access to food. A major risk to consider for the future is an increase of famines at world scale. Poor harvests due mostly to droughts but also to water pollution or floods may threaten food security in some places and trigger large-scale migration. In poor countries that are suffering ongoing water scarcity (see Indian River Interlink example on page 39), the resulting crop failures may be a factor in increasing suicide rates.

Famines and wars linked to water can cause widespread population displacement. In Syria, one of the many underlying factors leading to the current conflict has been a devastating drought. According to the Red Cross, 60% of Syria's land experienced severe crop failures between 2006 and 2011. As a result, 800,000 Syrians lost their entire livelihood and between two and three million people were driven into extreme poverty. This led to a massive exodus of more than one million farmers, herders and rural families from the countryside to cities. Next to the influx of Iraqi refugees, this put additional strains on the local population. That wave, combined with exceptionally poor economic conditions and a violent population uprising, helped ignite Syria's ongoing civil war.

> **"Failure to address climate change and water crises will forcibly displace more people."**[93]
> *World Economic Forum (2016)*

Given population growth and increasing water scarcity, such problems are likely to intensify in the future, in particular conflicts related to the nexuses "water-food" and "water-energy". At a further extent, water could even be weaponized, therefore entailing a man-made geopolitical risk.[94] In regions where aquatic resources are precious, whoever controls them holds a significant advantage over the other users.

8.4 Mitigation Measures and Consequences for Re/Insurance

> **"Water security is one of the most tangible and fastest growing social, political and economic challenge faced today."**[95]
> *World Economic Forum (2016)*

Efforts have intensified in recent years to reduce the risk of water-related conflicts by means of national and international law. For example, the UN Convention of the Law of the Non-Navigational Uses of International Watercourses was introduced in 1997. It is the only universally applicable treaty governing shared freshwater resources. The Convention provides a framework of principles and rules governing the resolution of inter-state disputes, namely the equitable and reasonable utilisation of freshwater resources, the obligation not to cause harm to other riparian states and obligation of prior notification about any planned measures on existing waterways.[96]

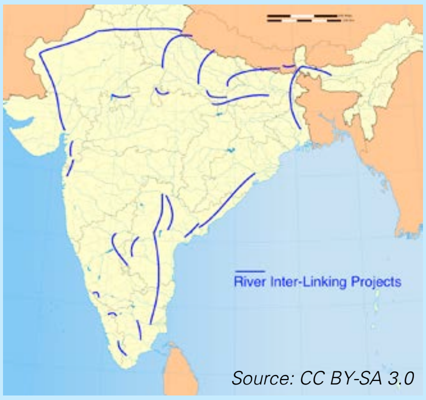
Bilateral and multilateral treaties over the use of shared water resources have proven fairly effective mechanisms of conflict-resolution. There are more than 200 treaties currently effective globally. Today their main objective is to provide governance for the usage, development and protection of shared water resources among riparian nations. Research has shown that water treaties can be quite an effective mitigant for potential conflicts.[97]

Such conflicts can have a significant impact on loss ratios in life, health, property damages, business interruption and motor. Re/insurers should be aware of the risks and take them into consideration when considering their global reach.

Rivers Inter-Link, India

Over recent decades, India has undergone massive growth in both population size and economic productivity – and while this growth is slowing, the country remains the world's fastest-growing major economy[98] with a population not set to stabilise until around 2060.[99] Such rampant growth has been placing an increasing strain on India's already stretched natural resources, and the country is seeing increasing demand for water for drinking, irrigation and use in industry. By 2030, India's water supply is expected to meet only half of the demand.[100]

The capacity of India's natural water supply to meet its growing national demand is hampered by significant spatial and temporal variance in freshwater availability: most of the country's annual rainfall comes during monsoon season – the four month period between June and September – and most of this rain falls across the northern and eastern regions of the country.[101] On top of this, India often goes through years with particularly high monsoon rainfall and flooding followed by years with low precipitation and drought, resulting in a significant year-to-year variation in water stress.



Source: CC BY-SA 3.0

India's rural heartland is particularly affected by these ongoing water shortages, leading to thousands of suicides, farm shutdowns and massive displacement towards cities, thus causing rising social instability.[102]

In 1980, the Indian government proposed a major engineering project designed to resolve this problem of mismatched water supply and demand. Developed by India's National Water Development Agency (NWDA),[103] the Indian rivers inter-linking project is a plan to construct a 15,000km network of canals and tunnels capable of transferring up to 174 billion cubic metres of water each year, at an estimated cost of US$168 billion.[104] The initiative is underpinned by the idea that linking rivers together will allow water to flow from areas with an excess of water to those where it is scarce – in doing so, preventing flooding in areas where water is plentiful and providing much-needed water for drinking, agriculture and industry in areas that would otherwise be hit by drought.

The project spans a total of 67 river linkages grouped into Himalayan, Peninsular, and Inter-state components.[105] Interlinking of rivers has been implemented successfully in India and elsewhere in the past, and supporters of the project argue that it is a vital step towards achieving water security in India. After years of planning and discussion, the project finally began in September 2013 with the linking of the Godavari and Krishna rivers, the second and fourth longest in the country.[106] However, an aqueduct was breached just days after the link was unveiled – a failure that has been attributed to poor quality construction. The next link is planned to connect the Ken and Betwa rivers in the heart of the country, but this effort has been delayed into 2016 by concerns of possible impacts on the Panna Tiger Reserve.[107]

Although praised by its proponents as a potential solution to the worsening problems of water scarcity and flooding in India, a large number of prominent figures have spoken out against the river linking project, arguing that its feasibility and possible economic, social and ecological implications have not been studied in detail. Concerns have been raised around the venture being far more expensive than predicted, causing large-scale displacement – with the South Asia Network on Dams, Rivers and People (SANDRP) estimating that the project will displace nearly 1.5 million people from their homes – having severe impacts on wildlife, and introducing significant uncertainties around issues such as environmental pollution.[108] In light of these concerns, people are imploring the Indian government to exhaust other options for securing water supply before embarking on such a vast project, including watershed development, rainwater harvesting, groundwater recharge, and optimisation of existing infrastructure and cropping methods.

In January 2016, with the objective to reduce the increase in suicide rates, India's government approved a new US$1.3bn insurance scheme for farmers. Premiums amount to 1.5% of the value of insured crops. In case of failed harvest due to natural cause, e.g. lack of water, farmers can reclaim their full value.[109]

9 WATER & REPUTATIONAL / REGULATORY / CUMULATIVE RISKS

- Failure to manage water risks can inflict serious damage on the reputation of a company or a government.
- These reputational risks are likely to increase as governments tighten environmental standards and increase disclosure requirements.
- **Re/insurance can help through products like business interruption insurance.**
- To protect against reputational risks insurers can also support the identification and assessment of reputational risks and encourage the integration of environmental, social and governance (ESG) considerations into its own core business processes.
- Cumulative risks reflect the cumulative effect of past decisions and multiple actions on an issue.
- **As well as assisting with products, such as business interruption, the re/insurance sector can help through its comprehensive experience in risk assessment of natural hazards. This can help customers anticipate the likelihood that an important water resource is likely to be impacted by multiple cumulative effects.**

9.1 Water Risks Create Social Pressure and Reputational Risks

Water risks, especially water scarcity and pollution pose not only a direct threat to the local population and environment but also to the operation and corporate reputation of industries. Reputational risks for companies are particularly common in developing countries where infrastructure and/or regulation may not be sufficient to provide all users with access to safe and reliable drinking water supplies.[110] This can be dramatically amplified where the region is highly exposed to extreme climatological events such as droughts. The risks are not limited to the internal operations of water-consuming companies: unsustainable water management practices within the value chain can also escalate and harm the reputation of a company.

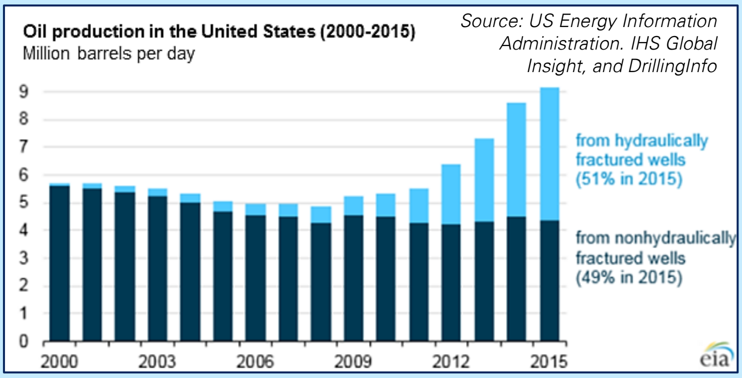
Water is a highly emotional natural resource. Reputational exposure can escalate to loss of customers and market shares due to negative perceptions that stakeholders might develop around a company's decisions. Water-intensive industries such as food & beverage, mining exploitations, agriculture, electric production or forestry are mainly concerned. Many industries have already had to abandon or modify plans or operations due to conflicts with communities and due to protests from activists and local residents (see Fracking example on page 41). In extreme cases, the conflict between groundwater use for industry and for drinking water has led to the loss of operating licenses for water intensive operations.

This adds additional pressure on companies to implement sustainable water risk management and to minimize negative impacts on water catchments and groundwater sources. In mining companies for instance, good water management helps limiting conflicts with local NGOs and governments (see Mining Water Treatment example on page 33). On top of cost savings and water efficiency, the company increases its brand value.

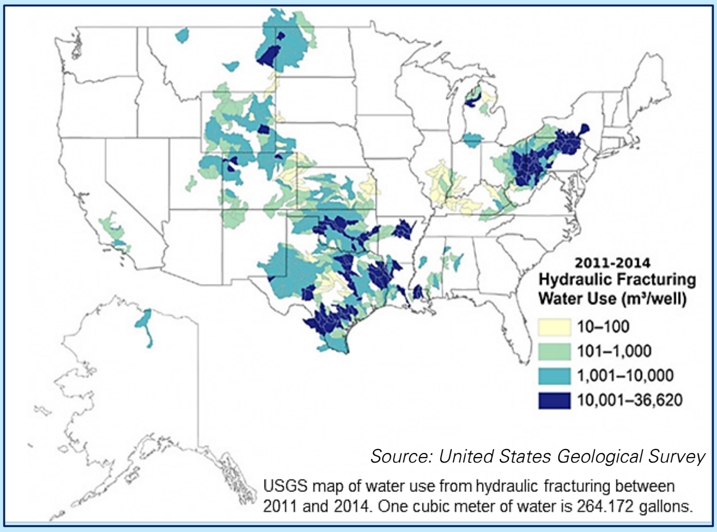
Water use disclosure is already a component of some of the environmental reporting standards for large corporates, for example the UK standards[111] set out by the Climate Disclosure Standards Board (CDSB). As awareness of water scarcity increases, the focus may move from voluntary usage disclosures to usage targets and quotas for large corporates. There is also potential for water usage to become a component of responsible investment criteria (see Water Footprint example on page 43).

Fracking

Hydraulic Fracturing (fracking) is a well-stimulation technique, whereby rock is fractured by injecting a high pressure mixture of water, solvents and sand in order to release oil and natural gas.



The origins of fracking date back to the 1940s. The technique was initially slow to develop, accounting for a mere 2% of the total US oil production by 2000. It boomed in the US with exploitation of shales (oil shales, gas shales). By 2015, it accounted for over half of total US oil production, driving the US to become the world's leading oil producer.



USGS map of water use from hydraulic fracturing between 2011 and 2014. One cubic meter of water is 264.172 gallons.

Fracking water consumption

Fracking is extremely water intensive, with an average well using 10 to 30 million litres of water over its lifetime. This high level of consumption increases the risk of local water stress, particularly in relatively arid regions. In addition the significant water usage often results in the requirement for the delivery of large volumes of water, usually via road or through new piping infrastructure.

Currently, fracking has only been significantly deployed across the US, Canada and China, with substantial social and political opposition in Europe, due to potential water-linked environmental concerns.

Water contamination concerns

Fracking fluids contain a range of chemicals and compounds, some of which are potentially toxic: oil, metals, and natural radioactive metals such as uranium and thorium. In both the US and Europe, research and public debate has centred around whether the chemicals used in fracking are carcinogenic, and whether it is possible for chemicals injected with the fracking fluid to enter the shallower aquifer from the underlying shale bed. Concerns around potential contamination of groundwater were the primary driver behind the 2015 fracking ban in New York State.[112] Moreover, the injected fluid partially comes back to the surface when the injection is stopped and this return flow must be treated. In the US, it used to be reinjected in deep aquifers, above or below the shale bed, which is now forbidden by new regulations.

Insurance industry implications

The high use of water for fracking presents insurers with underwriting challenges related to the transportation, storage and treatment of water. More significantly however, given the potentially emotive and controversial nature of fracking, re/insurers are presented with significant reputational risk when covering fracking operations. Property damages, especially affecting residential areas, may occur resulting from induced seismic activity, sometimes of high magnitude. In addition the dual uncertainty around the impact on health of fracking chemicals and their ability to enter the water table, presents potential tail risks to re/insurers that need to be carefully considered.

9.2 Regulatory Risks

In July 2010, the United Nations Organisation conferred access to water the legal status of fundamental human right. In South Africa for instance, the Free Basic Water policy implemented since 2000 ensures households a free water allowance equal to the World Health Organisation's recommended allowance. Every household has a right to get at no cost 6 cubic meters of water per month, calculated on a basis of 25 litres per capita and per day for a family of eight. Each municipality has the ability to decide if the service is made available to everyone or only to the poor. However, in most places worldwide such policies cannot or are not implemented.

For a government or a governmental agency, being unable to prevent or address water issues can induce loss of trust from the population. As reputational pressure increases, many local and national governments are responding with more stringent water policies. This provides environmental groups and citizens with a new leverage: the opportunity to issue lawsuits and legal proceedings. If unanticipated or ignored, these regulatory changes can prove costly to companies and, in some cases, interrupt or limit industrial activities in particular geographic areas.

9.3 Cumulative Risks

In addition to reputational risks, water resources can be cumulatively affected by human or natural activities. Observing and anticipating these cumulative changes can sometimes be difficult, potentially presenting unique challenges for water-users and their insurers.

Cumulative effects are changes to environments which are the result of a combination of historical, current and likely future actions. They tend to be non-sudden and potentially predictable, however it can be very difficult to halt a cumulative change. Attributing a cause is often not easy as the contributing factors in environmental changes are varied and often of low in magnitude when considered individually.

Cumulative effects impact water resources in terms of both quality and quantity of the available resource. Accumulated extraction of water can deplete the underground supply, or “dry up” rivers. Changes in land use over wide catchments areas can result in the accumulation of run off, which contributes towards water pollution. Each individual point of pollution might be considered negligible, and therefore permissible, but at the catchment level, these pollutants accumulate into single water sources.

It is often the users themselves who both contribute to and suffer from the accumulation of small impacts that lead to significant changes in the resource.

The scale of users who can be affected by water resource loss ranges from small businesses up to entire sectors. One of the critical impacts for a water user is the risk of interruption to the normal business operations. As reported by the BBC in 2015, water shortage fears in Brazil led one launderette operator to state the following *"We have survived recession, hyperinflation, arbitrary changes in legislation and a complex bureaucracy and tax system. We were also robbed twice. So at this point I didn't think a day would come in which I would seriously think about closing my business. But how can I operate a launderette without water?"*[113]

Single, large users such as dams or water-extraction facilities, who share the resources with numerous other small-scale activities, can become easy targets for criticism and even legal action, presenting liability or licensing risks for those operators and consequently their insurers. In the absence of an understanding of how the water resource is used on its own geographic scale, potentially an entire river catchment area, deciding which users are attributed causal responsibility for cumulative effects can be highly speculative.

A Water Footprint, What Is It?

The Water Footprint as a concept was developed to understand how production and consumption choices are affecting water resources. The methodology aims to map and quantify Green, Blue and Grey Water Footprints* through a four phase assessment:

1. **Goals and scope**: Define for what level of scale and with which aim the assessment is to be conducted.
2. **Accounting**: Data collection and calculation of the Footprint, according to a Water Footprint methodology.
3. **Sustainability**: Analysing the "water balance" between water resources and users in terms of:
   i. Environmental sustainability: Water use must not exceed the maximum sustainable limits of a freshwater resource.
   ii. Resource Efficiency: Water use measured per unit of production. The less water is used per unit, the more efficient the production.
   iii. Equitable Allocation: Analysing the fairness of water distribution among horizontal and vertical levels of users.
4. **Response formulation**: (Re)-define a response strategy based on the previous analysis to achieve the aim formulated in step 1.

The development of the assessment allows to make the so-called total "virtual water" visible on different levels of scale, individuals, industrial processes, companies and entire value chains, or on regional and national levels. Typical standard Water Footprint assessments are:

- **Company Water Footprint:** Measurement of the total water consumed to produce goods and services as well as clarifying the water risk for production. **An uninformed company can be exposed to: reputational risks, credibility, credit rating and additional (insurance) costs. Therefore a Water Footprint is often on the agenda of leading companies.**
- **Product Water Footprint**: Measurement of the amount of water that is consumed and polluted in all stages of the production of a single unit. Identifies water scarcity as well as water degradation in comparison to the water quality standards. The final result illustrates how much pressure the production of the unit puts on the freshwater resources.
- **Regional/National Water Footprint:** Measurement calculated from two different perspectives: production by and consumption of all the goods and services by the people that are living in a certain geographical area. Exported and imported products are taken into account when calculating the water footprint accordingly.

A Water Footprint can give a detailed view of water-related business risks, water in the economy as a whole and water dependency on different levels of scale. For a water-intensive company, assessing its Water Footprint ensures a higher awareness of its exposure to some water risks and a better management of its water efficiency.

Some exemplary Water Footprint calculations in products are:

Source: Adopted from The Water Footprint Network

**Green Water Footprint: Amount of rainwater stored in the soil required to make a product, either by evaporation or direct use.*
Blue Water Footprint: Amount of surface and groundwater required to make a product, either by evaporation or direct use.
Grey Water Footprint: Water required to dilute pollutants so that the quality of the water remains at or above agreed water quality standards.

9.4 Role of Re/Insurance - Anticipating the Risks

> **"The time for talking about the threat of water scarcity and poor water quality is over; now we need to act."**[114]
> *Ruth Mathews, Executive Director of the Water Footprint Network (2013)*

With so many variables, predicting the likelihood of a water resource to be at reputational, regulatory or cumulative risk is not an easy task. The re/insurance industry, as a financial service provider, can support their clients. Water-related business interruptions, e.g. those caused by order of authorities, are usually not covered by traditional re/insurance solutions: some insurers have started to develop risk mitigation solutions for business interruptions which are not triggered by physical damages.

To protect against reputational risks re/insurers can also support their identification and assessment with respect to water risk management. By integrating environmental, social and governance (ESG) considerations into its own core business processes, i.e. underwriting and investment decisions, the re/insurance industry can facilitate the development of sustainable business practices. This approach strengthens the client relationship and mitigates reputational risks for both clients and the re/insurance industry.

As for cumulative risks, a set of key common drivers can be identified, that increases the likelihood of a specific water resource being at heightened risk of cumulative effects. These drivers include:

- Large scale changes in land-use, particularly in river-catchment areas: An examination of aerial photos over a river catchment area or a groundwater extraction area can indicate, over time, whether or not the land use is changing significantly. Clearance of forestry for agriculture can be an indicator of a location that is at risk of water stresses. Similarly, urbanisation and increases in the amount of hard-surface areas can indicate likely reductions in surface water quality.
- Water resources which are shared by non-cooperating jurisdictions: In many places, rivers, lakes and underground water sources cross political borders. Examples of such political co-operation are becoming more commonplace. The Mekong River Commission is one such example of "cross border" political cooperation that is specifically designed to the management and development of water and related resources of the Mekong River. However, it should be noted that China (where the Mekong water comes from, in the high mountains) is not part of the Commission.
- Going further, some companies are now evaluating the true cost of their water externalities in terms of risks impacts and missed opportunities (see The True value of water on page 45).

The re/insurance industry has a comprehensive experience in risk assessment of natural hazards. The digitalisation trend including increasing use of drones and aerial images enables a much faster and more accurate risk assessment and emergency response. Insurers can use this knowledge to anticipate and advise their clients in terms of water risks.

The "True Value" of Water

Source: Adapted from Johann Clere, Veolia

"You don't manage what you don't value"

Organisations such as the World Business Council for Sustainable Development (WBCSD) have been promoting the need to frame the True Value of Water for sustainable growth.

More and more, large industrial water users, cities and financial communities are now reaching a turning point where they are showing interest in understanding externalities around water.

Understanding first the "true" cost of water is a key starting point. It looks beyond just the price of the cubic meter as it encompasses also monetisation of water related risks having already materialised for cities and industries while looking as well as indirect costs and missed opportunities.

Indeed assessing the true cost of water is not straightforward and includes several aspects:

1. **Direct costs**: Water price, cost of treatment plants and of other infrastructures. In Europe the price of potable water to the public varies from 1€/m^3 (Italy) to 6.4€/m^3 (Denmark). The water resources available and the state subsidies vary from one country to another.
2. **Indirect costs**: Such as cost of public relations, Corporate Social Responsibility (CSR), lawyers, fines.
3. **Risks impacts:** Such as remediation costs and downtime in case of pollution, drought, flooding.
4. **Missed opportunities**: Positive impact of good water management in terms of investors' attractiveness and opportunities in creating new revenue streams by selling treated wastewater to third parties for reuse. It includes as well new financial opportunities to capture, such as negotiating better insurance premium when mitigating risks and enhancing resilience & robustness. Credit Rating companies are also starting to assess how companies handle water management with a potentially strong impact on the cost of capital.

An example of change of paradigm for Californian Oil & Gas Companies

In California, the extraction of 1 barrel of oil yields up to 30 barrels of dirty water as by-product. This water cannot be reinjected anymore into the ground, as a result of pressure from farming industries, NGOs and new environmental regulations. However, it can be sold to third parties after treatment, e.g. for cooling or irrigation. Due to global reductions of oil prices and to increasing water scarcities in the vicinity of the Californian extraction fields, a new market landscape emerges: in the future, for one barrel of oil worth US$40, oil & gas companies could potentially earn US$20 selling on the spot market the water extracted and basically treated.

Being water positive in a very water-stressed environment could enable these oil companies to become more and more 'water companies', with oil almost becoming a by-product.

Valuing water externalities helps in identifying and unleashing disruptive shared value creation opportunities. This emerging concept of 'true value of water' could go along with an increasing need for re/insurance products.

10 CONCLUSION

- Water Risks have always been present but the global increase in population and increasing complexity of human activity mean both likelihood and severity of water risks are increasing.
- Due to the interconnecting nature of water on a global scale, it is in everyone's interests to consider and mitigate water risks to eliminate the downside and increase the potential for economic prosperity for all.
- **Re/insurers have a key role to play through the products they provide and the investments they make.**
- **Equally re/insurers have a unique perspective on risks and valuable evaluation tools.**

While water risks such as scarcity, contamination, water-borne diseases, and issues linked to water treatment, social conflicts, or reputational / regulatory risks are not new phenomena, they are often critical. Most of the time they consist of an accumulation of risks triggered by multiple factors, characterized by their complexity, uncertainty and global interconnectivity.

Yet, major water threat events are increasing in frequency, geographical scale and severity of impacts, while the human population directly affected by these risks undergoes a rapid and uncontrolled growth. The enigmatic nature of water aggravates the difficulty in assessing and quantifying the risks. As a consequence water risks are often underestimated, disregarded or simply ignored. It results in a global lack of preparation for future impacts.

10.1 Impacts on Re/Insurance: Liabilities & Opportunities

Water supplies are a key utility. As a shared resource, water mismanagement will impact all uses and all users with multiple related losses. In sparsely insured countries, water risks are measurable mostly in terms of economic and human losses. In wealthier countries on the contrary, costs in insured losses can be significant. Water risks have an emerging potential to generate impacts on a wide range of areas such as loss of business, property, business interruption, agriculture, third party liability, environmental impairment liability, errors and omissions, mortality and health.

For the re/insurance industry, a "business as usual" approach with neither a new course of action nor a development of mitigating strategies could result in the impacts of water risks on liabilities significantly increasing. With the upcoming intensification of water risks, it is challenging to evaluate the potential level of future claims.

If well assessed, water risks may transform into business opportunities. Better access to water and more reliable water quality can support an economic development that will bring more people in a position to afford insurance. Providing re/insurance for well assessed and better understood water risks will also contribute to building long-term financial resilience. In addition, well considered and structured infrastructure projects targeting water supply, treatment and sympathetic use may represent good investment opportunities at a time of low interest rates.

Lastly, water issues generate strong emotional responses, with large-scale visibility. Such high public scrutiny could be used as an opportunity for re/insurance companies to step in as forward-looking and attractive companies, by raising early-awareness on such water risks and discouraging poor water management. An additional benefit is the respectable social image that usually comes with investing in sustainable projects.

10.2 What Re/Insurance Can Bring to the Table

One of the greatest difficulties when addressing water risks is to secure water resources, both in terms of quality and quantity, in a given location without compromising downstream resources. This is particularly challenging since water often has no identified ownership. Most resources are currently inadequately managed, wasted or spoilt, which translates into excessive costs of usage and additional expenses due to inadequate water management. A thorough transformation of the way we see water is required: from taking it for granted to treating it as a precious resource, in both terms of social and commercial value.

Re/insurance companies could play an active role here:

- Sharing their risk management expertise: The re/insurance industry is recognized for its expertise in identifying and assessing risks, preparing for disasters as well as evaluating potential losses and damages. In response to evolving water threats, some of which could be very costly and have a long return period, new comprehensive approaches in risk management strategies for water issues could be defined. Identification of water-related risks and adaptation to new trends and to local disparities would ensure more effective long-term risk mitigation.
- Raising knowledge and awareness: Re/insurers seek long-term visibility on their exposure. It can be achieved by setting new partnerships with scientific and technical experts to gain practical knowledge. Sharing awareness and expertise of these risks with other stakeholders could help prevent upcoming losses.
- Fostering innovation in water-related domains: Re/insurance companies can offer assistance to or favour customers that are adopting innovative technologies, new strategies or approaches in order to achieve resilience over worsening water risks. Re/insurers can also invest in promising water-related projects to promote efficient water management.

> **"Many re/insurers are realizing the power they have and the moral choices they must make in terms of where they invest"** [115]
> *Intelligent Insurer, Wholesale insurance journal*

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APPENDIX

Typical Pollutants

The most common pollutants are mineral oil hydrocarbons, such as petrol, diesel/heating oil and kerosene. Damage to soil and groundwater is predominantly in the vicinity of storage tanks. These do not spread particularly far in groundwater, generally to a distance of no more than 10–100 metres.

- Benzene, toluene, ethylbenzene, and xylol (BTEX) are aromatic hydrocarbons. They are used as solvents, for example in lacquers and paints, but also to clean metal parts. Benzene is also present in petrol (up to 3%) and is carcinogenic. Aromatic hydrocarbons can spread up to 1km in groundwater depending on local specificities.
- Volatile halogenated hydrocarbons (VHHC) are solvents that were widely used in the past. These substances were used almost ubiquitously: in all metal processing, in chemical cleaning and in paint manufacture. They can spread up to 1,000m in groundwater; in individual cases, they have spread up to 12km. Some chlorinated hydrocarbons (CHCs) are carcinogenic.
- Polycyclic aromatic hydrocarbons (PAH) are contained in the tar that is produced in the distillation of coal in coking plants and gasworks. PAHs occur in gasworks and steel mills when railway sleepers are treated with carbolineum oil, or by burning wood in chimneys. PAHs are carcinogenic.
- Dioxin and furan are formed during low-temperature combustion processes: in waste incineration plants, ore sinter plants in iron- and steelworks, and in fires involving plastics.
- Polychlorinated biphenyls (PCBs) were used ubiquitously: for example as transformer oil in transformers, or as plasticisers in concrete joint seals. They are now internationally banned.
- Pesticides such as dichlorodiphenyltrichloroethane (DDT) and hexachlorocyclohexane (HCH = lindane) are normally only found in chemical industry production plants in the form of dangerous waste in the soil and groundwater.
- Heavy metals such as arsenic in coal ash (coal-fired power plants), chromate (chrome component used as wood preservative), lead in lead glass works and battery factories, chrome in metal processing, cadmium in zinc works, and in plastics processing as a plasticiser, and copper in copper works.

GLOSSARY OF ABBREVIATIONS

- CDP: Carbon Disclosure Project
- CDSB: Climate Disclosure Standards Board
- EDC: Endocrine Disrupting Compounds/Chemicals
- EPA: US Environmental Protection Agency
- ESG: Environmental Social Governance
- EU: European Union
- GMR: Great Man-made River
- IDA: International Desalination Association
- IPCC: Intergovernmental Panel on Climate Change
- IWMI: International Water Management Institute
- MDG: Millennium Development Goal
- MSR: Mega Storage Reservoir
- NBCR : Nuclear, Biological, Chemical and Radiological
- NWDA: Indian National Water Development Agency
- OECD: Organisation for Economic Co-operation and Development
- SDG: Sustainable Development Goal
- UN: United Nations
- UNEP: United Nations Environment Program
- US: United States
- USGS: United States Geological Survey
- WEF: World Economic Forum
- WHO: World Health Organisation
- WIN: Water Integrity Network
- WWAP: World Water Assessment Programme

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