AQUA

WATER ES·SEN·TIALS

The Future of Water:
A human and business priority

Point-of-View

BDO

Content

Water is the resource of fundamental importance, the scarcity of which could slow down the global development

Key figures

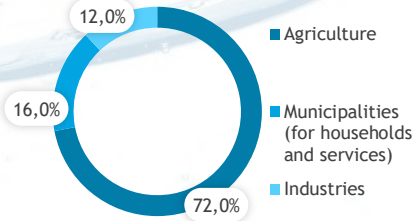
71,0% of Earth is covered in water

Water accounts for up to **75,0%** of human body weight

10,0 billion tonnes of freshwater is used worldwide everyday

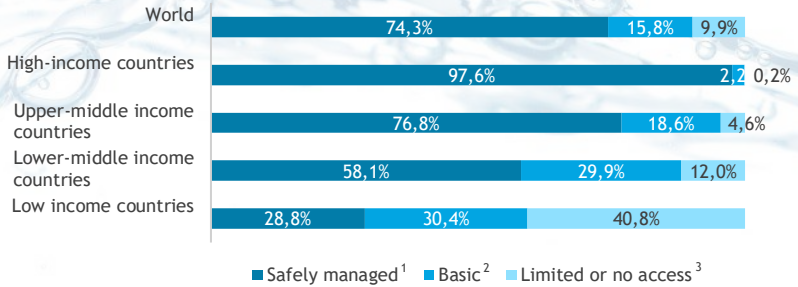
The **origin of the water** is still under debate — whether it emerged from the **Earth's mantle** or was brought by **asteroids and meteorites** billion years ago. However, it is difficult to overestimate the **importance of water** during the world history. Water plays **a fundamental role in people's lives and global economic development.**

Global freshwater withdrawals usage as of 2021



In the modern world, especially in **developed countries**, water **is taken for granted** and people **do not realise its true value.** However, in 2021, **more than two billion people live in water-stressed countries**, of which **733,0 million live in high and critically water-stressed countries.**

Share of the population with access to drinking water facilities, 2020



Water scarcity **adversely affects production volumes** and, therefore, **global economic development**, as well as **causes significant socio-political tensions,** such as **conflicts in Africa and the Middle East.**

Source: Our World in Data website; UN Water website; The World Counts website; Media overview
Notes: (1) Water source located on premises, available when needed and free from contamination; (2) Water source that is located closer than 30 minutes roundtrip; (3) Water source that is located farther than 30 minutes roundtrip or water from unprotected source, such as river, dam, lake, pond, etc.

Efficient water management and introduction of innovative technologies will shape the future of water industry

Consequences of the water crisis

Climate change increases the number of **water-related hazards**, such as **floods and droughts worldwide**

Unreasonable water management increases the number of people **suffering water stress worldwide**

Lack of access to safe drinking water and sanitation causes a **variety of diseases and lead to people's death in low-income countries**

Poor access to water in low-income countries causes **education crisis** as children spend much time **of studying**

Lack of basic water and much **time spent gathering water** accounts for **billions of dollars in lost economic opportunities**

Water for the agriculture sector is becoming **scarce** due to the **growing population's demand for food**

Selected trends that shape water industry

- Reusing water to support a circular economy
- Implementing smart and intelligent network technologies
- Rising popularity of desalination
- Applying advanced filtration techniques
- Getting access to quality data
- Increasing green hydrogen generation

Future Water Outlook

2025 By 2025, two-thirds of the world's population is projected to live in **water-stressed regions.** With the rising population, **global agriculture alone will require additional one trillion cubic metres of water per year**

2030 If current water usage trends don't change, it is forecasted that **water deficit will reach 40,0% on the global level by 2030**

2040 It is estimated that in 2040, there will not be enough water to **meet the world population's demands** and **keep the current energy and power solutions going** if water management **remains poor**

Source: BDO Centers analysis

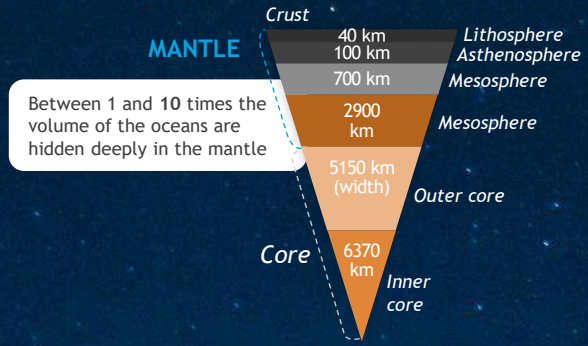

ORIGINS AND TYPES OF WATER ON EARTH

To this day the scientists are actively researching to agree on one single theory of the origins of water on Earth

The Earth is widely known as a ***"Blue Planet"*** due to abundant water on its surface. Yet, the origins of water on Earth remains a major debate subject with two competing theories of how the Earth went from the "rocky nothingness" to a water-rich "pale blue dot"

Theory 1 — From Formation of Earth

The first theory argues that water was on the Earth since its beginning, as rocks found in a layer of the Earth, the mantle, contains water in the form of hydroxyl groups trapped with minerals, which can be released during volcanoes. As the pressure falls, the water vaporises and explodes into atmosphere as steam to later condense and fall back into Earth, filling the rivers and oceans.



Theory 2 — From Outer Space

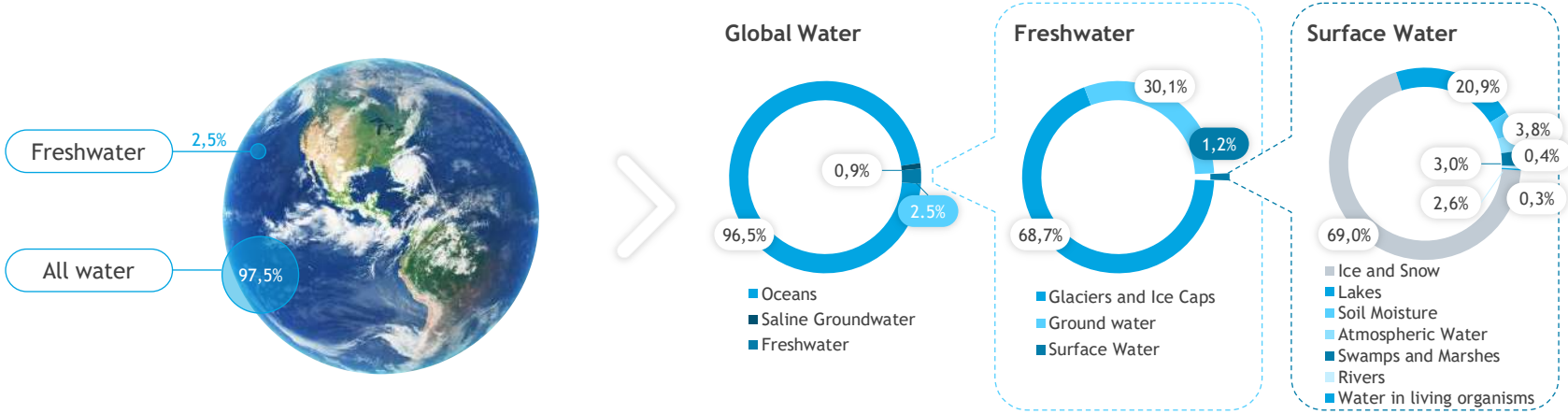
The second theory highlights that water arrived from outer space in the final stage of Earth's formation, mostly facilitated by water-rich asteroids and comets colliding with the planet. Since the ratio of hydrogen and deuterium in the meteorite water was close to that of terrestrial water, scientists concluded that asteroids and comets were the likely source of Earth's water.

It is highly likely that the truth lies in the middle and Earth's water is a combination of endogenous and exogenous sources

Source: Science Daily Website; Scientific American; Science.org; Harvard University

Less than 3% of all water on Earth is freshwater, yet only 1% is accessible, which makes it a rare resource globally

Earth's Water Distribution



While more than 70% of Earth's surface is covered in water, only a small percent of water is fresh and even less of it is easily accessible. Around 97% of all Earth's water is being saline or ocean-based, with only remaining less than 3% of freshwater.

Despite its importance for humanity, freshwater is an extremely rare resource, as water distribution is very uneven. Around 69% of freshwater is trapped in glaciers and ice caps, and another 30% is under the surface in the from of groundwater.

Source: USGS website; World Bank website; National Geographic website

ROLE OF WATER IN THE WORLD

Water is essential to support life on the planet, and it contributes to the global economy and social stability

Water touches **every aspect** of the world's development and has a **major impact on people's lives** in **biological, social, and political terms**. It drives **economic growth**, supports **healthy ecosystems**, and **is essential and fundamental for life itself**.

Biological & Geological

Being the **universal solvent**, water is **vital for the organisms** as it participate in the **oxygen and nutrients transportation** in the cells, as well as in **metabolism,** and **supports the cellular structure**. Water **makes up 60,0-75,0% of human body weight.** Moreover, water **links and maintains all ecosystems** on the planet. It **propels plant growth, supports native wildlife** and **provides dwellings** for multiple amphibians, insects and other water-birthed organisms.

Social and political

Every person has a right to **free fresh water access.** Contaminated water could **undermine efforts of combating extreme poverty** and **disease** in the world's poorest countries. Water is vital for the **access to energy sources**, while **uneven distribution of water** leads to **political conflicts between countries.**

Economic

Water is a **vital factor** for the **global production**, therefore reducing water supply would lead to **slower economic growth worldwide**. Water is extremely important for the number of **other economic sectors** as well, such as **food, agriculture, energy and gas, processing and transport industries.**

Roles of water

BIOLOGICAL AND GEOLOGICAL ROLE OF WATER

Water is a fundamental component of the Earth planetary development and a basis for evolution of the living systems

Biological role

All forms of life on Earth requires water, it is the major component of all living systems, occupying most of the cell's volume. Due to its properties water ensures processes that organisms require to live.

- **Water is the universal biological solvent** that is critical for the delivery of nutrients in the cells and the removal of metabolites
- **Water serves as an essential buffer** to support the regular temperature due to its high specific heat capacity and regulate pH in biochemical mediums
- **Water is a participant in many biochemical reactions** and the principal reactant in the **photosynthesis process,** which is vital for living organisms being the major source of oxygen in the atmosphere

Geological role

All water on Earth **forms a hydrosphere**, which is an important agent of geologic change through the hydrologic cycle.

Water shapes our planet by depositing minerals, aiding lithification, and altering rocks after they are lithified.

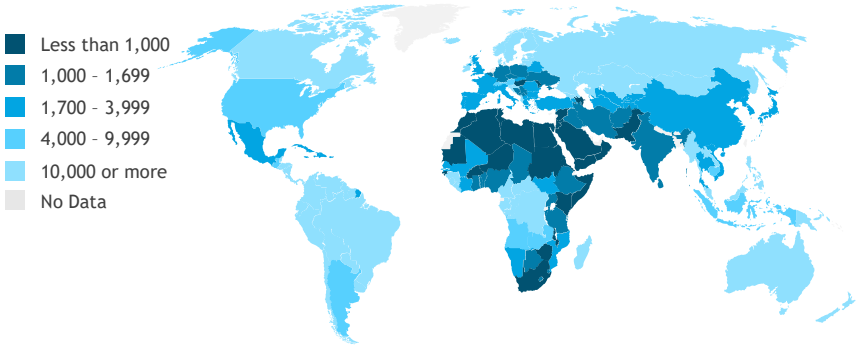
Hydrosphere comprises:

- **Groundwater,** which is located beneath the surface of the earth
- **Surface water** occurs on the earth's surface in streams, rivers, lakes, and reservoirs
- **Water in the air**

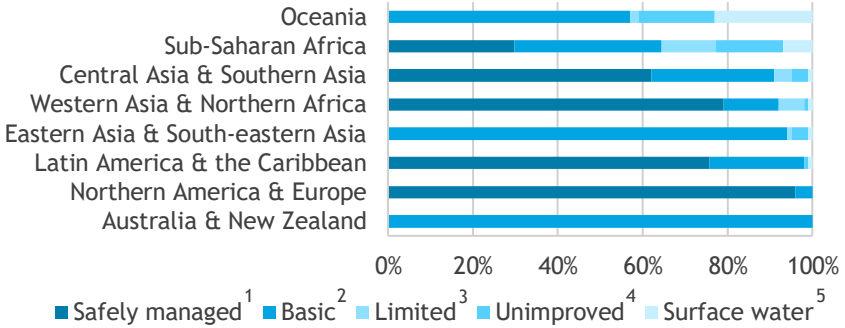
Water on the planet **constantly circulates** and transforms its physical forms between solid, liquid, and gas (water vapour). The ocean ensures global movement of water and **affects weather and climate** by storing solar radiation, distributing heat and moisture around the globe

Since the freshwater distribution is uneven around the globe, many countries face the risk of water scarcity

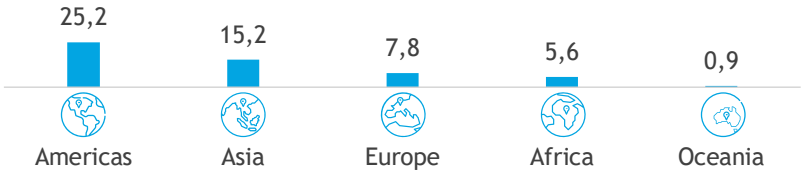
Freshwater recourses worldwide per capita, m³



Share of regional populations with access to various water sources worldwide in 2020



Global renewable water resources 2017, by region, thousand cubic kilometres



- Global renewable water resources on Earth **differ from region to region** due to the climate specific and geological characteristics. Meanwhile the access to water sources also depends on the economic development of the each region and country
- **The Americas has the largest renewable water resources** worldwide, namely 25,2 thousand cubic kilometres. **Brazil, Russia, the USA and Canada** are the countries with the biggest amount of renewable water resources worldwide
- **The Middle East and Africa experience water scarcity.** Most African countries have high drought risk, which is classified in terms of socioeconomic effects such as agricultural losses

Source: Statista website; Bloomberg website; The World Bank website

Notes: (1) Drinking water from an improved source that is accessible on premises, available when needed and free from contamination; (2) Water source that is located closer than 30 minutes roundtrip; (3) Water source that is located farther than 30 minutes roundtrip; (4) Water from unprotected dug well; (5) Water directly from a river, lake, canal, streams, pond and dam

Global warming leads to the rise of the sea level, increases flooding and causes massive disruptions worldwide

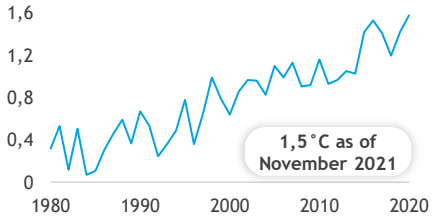
Climate change as a reason of the global sea level rise

- Record atmospheric greenhouse gas (GHG) concentrations and associated accumulated heat **caused rapid and intensifying global climate changes.** The GHG trap the heat in the atmosphere and cause **the planet to get hotter, which is called the greenhouse effect**
- The greenhouse effect is **the main reason for global warming.** Since 1980, the global annual temperature **has risen by 0,2°C,** which **has a negative impact on the water circulation processes.** Europe and Asia are the regions with the biggest temperature changes, which hurts the water cycle
- **Annual Arctic Sea Ice Area extremely decreased** at a CAGR of (-1,7%) for the last 40 years, which was **global warming consequences.** This abnormal reduction leads to the global sea level rise

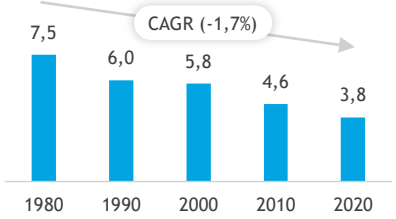
Floods as consequences of the global sea level rise

- **Due to climate changes, the risk of floods is increasing worldwide** during the last decades. The **coastal and low-lying, urban, and river areas** with frequent heavy rains are **the most vulnerable to flooding**
- **In 2020, 201 floods were recorded worldwide, most of which occurred in the Asia region.** The mortality from floods increased globally by 17,9% in 2020 compared to the 2000-2019 annual average. The most of fatal incidents were recorded in India mainly due to the weak preventing and rescue activities
- Floods cause a number of **short-term and long-terms consequences** for social and economical spheres. **Water supply disruption, property destruction, destroying of land for living and agriculture** are among most frequent consequences of the floods

Annual anomalies in global land surface temperature[1], in degrees Celsius



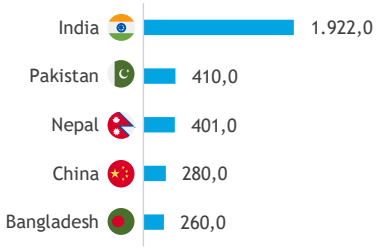
Annual Arctic Sea Ice Area, in million square kilometres



Global key figures in 2020[2]

- ↑ +23,3% — **201** floods worldwide
- ↑ +17,9% — **6.171** mortality by floods
- ↑ +54,5% — **45,0 Bn Euro[3]** economic loses

Top-5 countries by number of mortality from floods in 2020

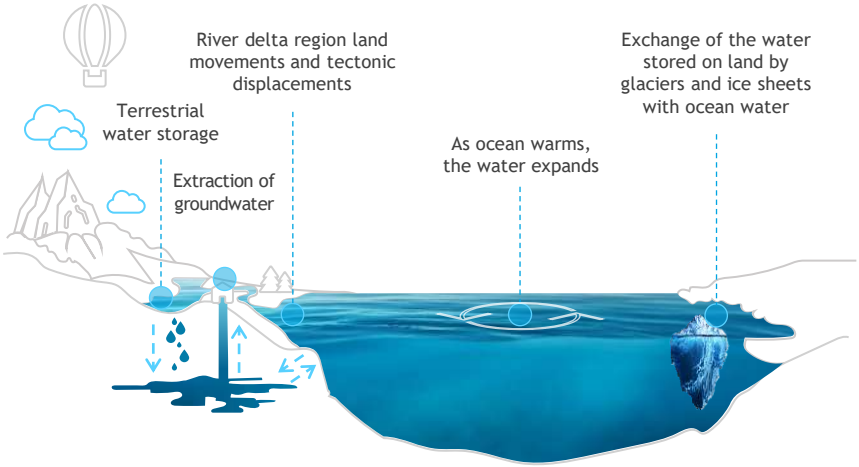


Source: UNDRR PreventionWeb website; NASA website; NRDC — Global warming — [2021]
Notes: (1) Compared to the 20th century average; (2) Compared to the 2000-2019 annual average;
(3) Numbers are converted from USD to Euro due to the exchange rate by ECB

Without immediate preventive measures the global sea level is projected to rise by around five times until 2050

Global warming **accelerates the sea level rise**, **which provokes** coastal erosion, worsen the quality of drinking and irrigation water, damage historical heritage, affect mobility systems in cities, as well as submerge farmland and natural landscapes.

What causes the sea level to rise?



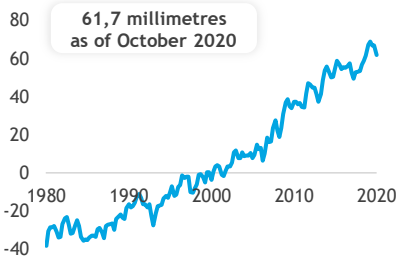
Ocean Warming
50,0% of sea level rise linked due to thermal expansion of water

Ice Melting
Polar Ice melting drops 430,0 gigatonnes of fresh-water annually into ocean

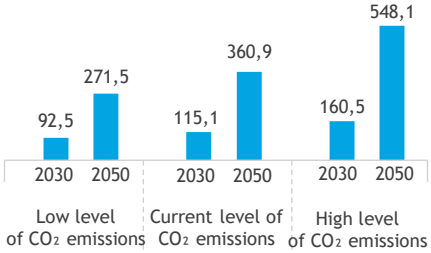
Deglaciation
Global loss of 9,0 billion tonnes of glacial ice since 1961

CO_2 emissions heated up our planet causing glacier recession and Ice melting. Depending on the increase in CO_2 emissions, **scientists are projected three scenarios for sea level rise by 2050.**

Global sea level rise[2], millimetres



Forecasted sea level rise by path scenario[3], millimetres



Source: NOAA — Climate Change: Global Sea Level — [2021]; U.S. Climate Resilience Toolkit website
Notes: (1) Measured relative to the 1993-2008 average sea level; (3) Measured relative to 2016 sea level

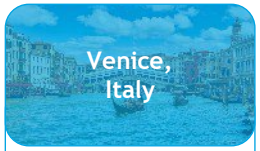
Therefore, governments are looking for solutions and measures to protect cities from vanishing under water

The major cities are expected to be affected by sea level rise and measures for prevention

Bangkok, Thailand

The city is located 1,5 metres above sea level and sinking **by about 30 millimetres** every year

Governmental measures, which includes cleaning-up of waterways, dam construction, planting trees



Venice, Italy

Sea level is rising and the city itself is submerged **by two millimetres** every year

Reinforcement of **flood barriers** straddling the Adriatic Sea and the Venetian lagoon

New York, the USA

According to the worse scenario, the sea is projected to **swallows all the city area**

Implementation of the NYC **Stormwater Resiliency** Plan[1] and The NYC **Wastewater Resiliency** Plan[2]

Liverpool, the UK

Sea level rise will **make disappear Albert Dock** — one of the most major British port

Amsterdam, the Netherlands

Located three metres below the sea level, Amsterdam **could lose up to 92,0% of its surface**

Proposed by oceanographers **Northern European Enclosure Dam Project**, which provides the common construction of **two major dams** in the English Channel and the North Sea

Rio de Janeiro, Brazil

The famous Copacabana beach and the airport may disappear

Scientists offer to experiment with various solutions, including **Sponge-cities[3] and Bold strategy[4]**

General ways of adoption to threats:

Seawalls and dam building
- Recycled plastic mixed with concrete

Rethinking roads
- Polystyrene insulation
- More bike lanes
- Flood resilient rodes

Strategic planting
- water-absorbing vegetations
- heat-absorbing trees

Innovative architectural features
- Barriers
- Drainage systems
- Floating cities

Source: TimeOut — 9 cities that could be underwater by 2030 — [2021]; National Geographic — Sea level rise — [2019]; Media overview

Notes: (1) Includes facilitate green roof deployment, timely public inform, as well as drainage network improvement; (2) Provides the development of pumping stations through static barriers installation, and seal building; (3) Combination of repurposed built space, rain gardens, ponds, and wetlands to store excess water; (4) Rio de Janeiro's transformation into a sustainable city with green areas protection and recycling promotion

Northern European Enclosure Dam is one of the joint initiative to address the sea level rise in the North Europe

Northern European Enclosure Dam (NEED) —

is a potential megaproject about **the construction of two major dams** in the English Channel and the North Sea **proposed by two oceanographers** — Sjoerd Groeskamp and Joakim Kjellsson. The project **is a possible solution to decrease the sea level rise** from the melting Arctic ice in the Arctic Ocean and save millions from losing homes and land. Scientists suggest **the dams would be more effective than individual countries taking actions.**

However, **enclosing the North and Baltic Seas will have a negative effect on wildlife and the environment.** Tides would be disrupted, affecting the way sediment, nutrients, and small marine life would circulate.

Estimated cost:
Around 300,0-400,0 Bn Euro

Estimated timeline:
50-100 years

Source: American Mereological Society — NEED: The Northern European Enclosure Dam for if Climate Change Mitigation Fails — [2020]; TU Delta — Damming the North Sea. Is that a good idea? — [2020]

Despite the global sea level rise, there are ecosystems that are drying up and are at risk of disappearing completely

Five Drying Rivers

1 ***Colorado River***
The USA, Mexico

Why: wide usage for agriculture, industrial and municipal needs. Over last century the rivers flow declined by about 20,0%

Proposed Fix: four American states[1] consider a programme to voluntarily reduce agricultural water use in the upper Colorado River basin

2 ***Yellow River***
China

Why: extensive usage for agriculture
Proposed Fix: In 1990 was establishes YECC[2] to manage the river's lower and mitigate the devastating effects of the destructive droughts and floods

3 ***Rio Grande River***
The USA, Mexico
Why: the river is highly depends on the rainfall, which declined in the recent years due to the climate changes

4 ***Teesta River***
India
Why: wide usage for irrigation and other uses

5 ***Indus River***
Pakistan
Why: agricultural, industrial and household activities

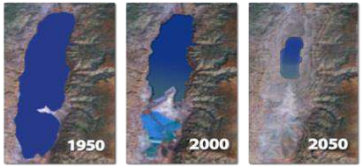
Five Drying Lakes

1 ***Aral Sea***
Kazakhstan, Uzbekistan

Why: Soviet Union's strategic diversion for irrigation purposes
Proposed Fix: splitting the sea, dam construction
Status: implemented
Aral Sea **is the fastest drying lake in the World** with **90%** of its surface water gone by 2021, due to combination of Strategic Soviet Union's diversion for irrigation purposes and otherwise dry steppe area of Central Asia. Even though the efforts to preserve the lake have been implemented, the Eastern Basin is **completely extinct**

2 ***Lake Urmia***
Iran
Why: damming the flow-in rivers

3 ***Dead Sea***[3]
Israel, Jordan
Why: diverting Jordan river flow
Proposed Fix: building canals
Status: not implemented, due to Middle East/Jordan/Israel conflict



4 ***Lake Chad***
Chad, Cameroon, Nigeria, Niger
Why: catchment area discharge, evaporation

5 ***Lake Eyre***
Australia
Why: evaporation

Source: NASA website, Science website Interesting Engineering website: Smithsonian website; China Daily
Notes: (1) Wyoming, Colorado, Utah and New Mexico; (2) Yellow River Conservancy Commission YRCC, a government agency under the Ministry of Water Resources of China; (3) Deepest point on Earth;

Global droughts are not only affecting rural areas but some cities, potentially leaving inhabitants without water access

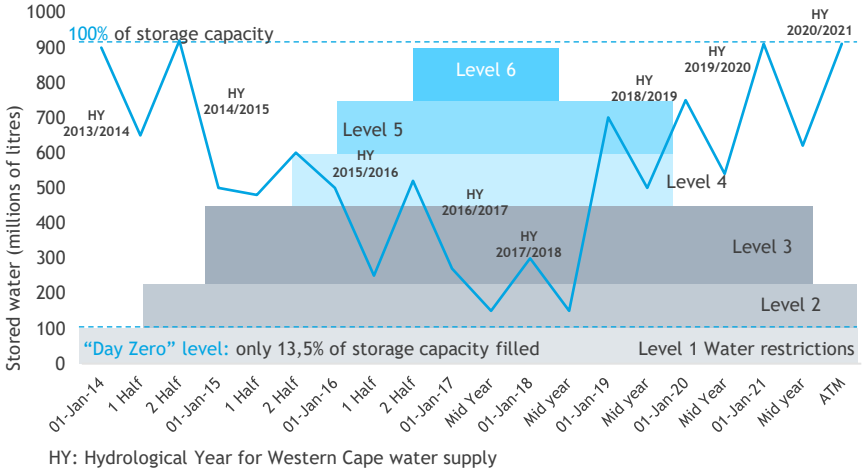
More than 2,0 billion people are living in countries under water stress and **3,6 billion people face inadequate access to water** at least one month per year. Meanwhile, water-related hazards have increased in frequency for the past 20 years. Since 2000, the **number and duration of droughts also increased by 29,0%**

The worst droughts in 2021 worldwide

1. Extreme weather conditions, from massive flooding to severe water shortages, **have affected Brazil in May and October**. The country **faced its worst drought in 91 years**, increasing fears of energy rationing, hitting hydroelectric power generation and agriculture while raising the risk of Amazon fires.
2. **In Madagascar,** hundreds of thousands of people were starving as a result of the **July drought**. WFP[1] reported that in some regions, **about 55,0% of people need action to protect livelihoods and reduce food insecurity**.
3. **In Iraq**, large swathes of farmland, fisheries, power production and drinking water sources have been depleted of water. **In the Ninewa governorate**, wheat production is expected to decrease by 70,0% due to the drought, while in the Kurdistan Region of Iraq production is expected to decline by half.

Cape Town Water Crisis

Cape Town Water Crisis in 2018 has been brought upon the Western Cape **due to severe droughts being starting in 2015** and led to the only **13,5% of the region's storage capacity filled**. As a response to the crisis, tens of thousands of pines and eucalyptus trees were chopped due to consuming 55 billion litres of water per year



HY: Hydrological Year for Western Cape water supply

Sources: World Meteorological organisation website; Ecological Threat Register website; Media overview; The UN World Food Program report — 'Hunger Hotspots' — [2021]; United Nations Office for the Coordination of Humanitarian Affairs website;
Notes: (1) The UN World Food Program;

SOCIAL AND POLITICAL ROLE OF WATER

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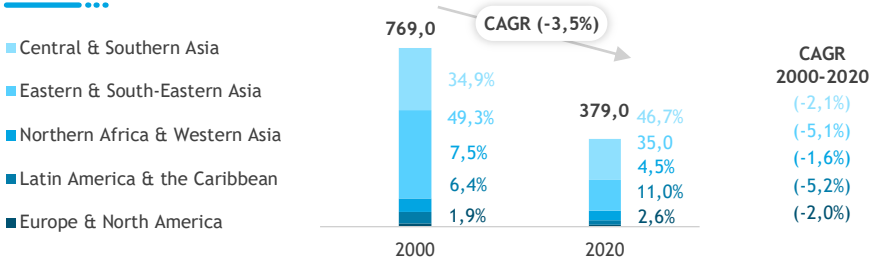
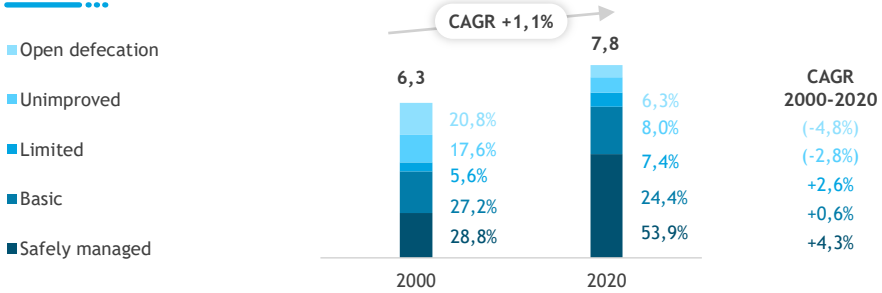
SOCIAL ROLE OF WATER

Global availability of drinking water and sanitation services has been actively increasing during the last decades

Number of people without basic drinking water services by region, million people



Global population with sanitation facilities supply by facility type[2], billion people



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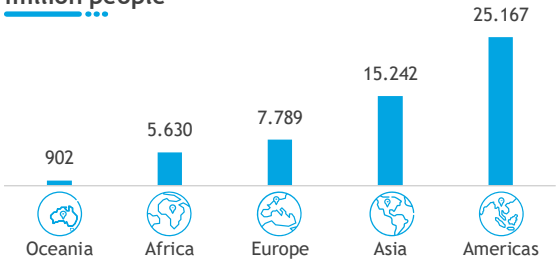


Total global renewable water resources amounted **54.730 billion cubic metres in 2017**

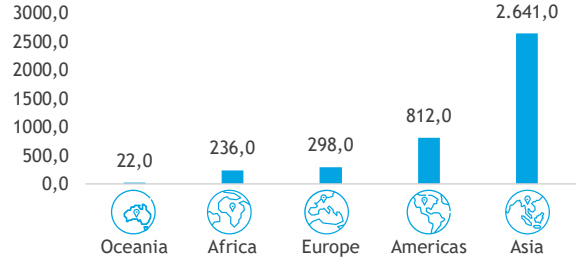
- Access to drinking water and sanitation are the basic needs for people around the world. Despite the **stable rise of water services accessibility** within the last decades, currently, **4,8% of the global population** still suffer from the **lack of drinking water services**, with almost a **half of which in the Central & Southern Asia**
- As of 2020, **4,2 billion people worldwide had access to safely managed sanitation services,** which was a 2,3 times increase during the last 20 years. Herewith, **6,3% of the global population still practised open defecation,** and 8,0% experienced unimproved facilities only
- **The Americas is the richest region worldwide in terms of renewable water resources.** Its share in the global renewable water resources **reached 46,0% in 2017,** followed by Asia and Europe, which shares **were 27,8% and 14,2% respectively in 2017**

Source: Statista website, Media overview

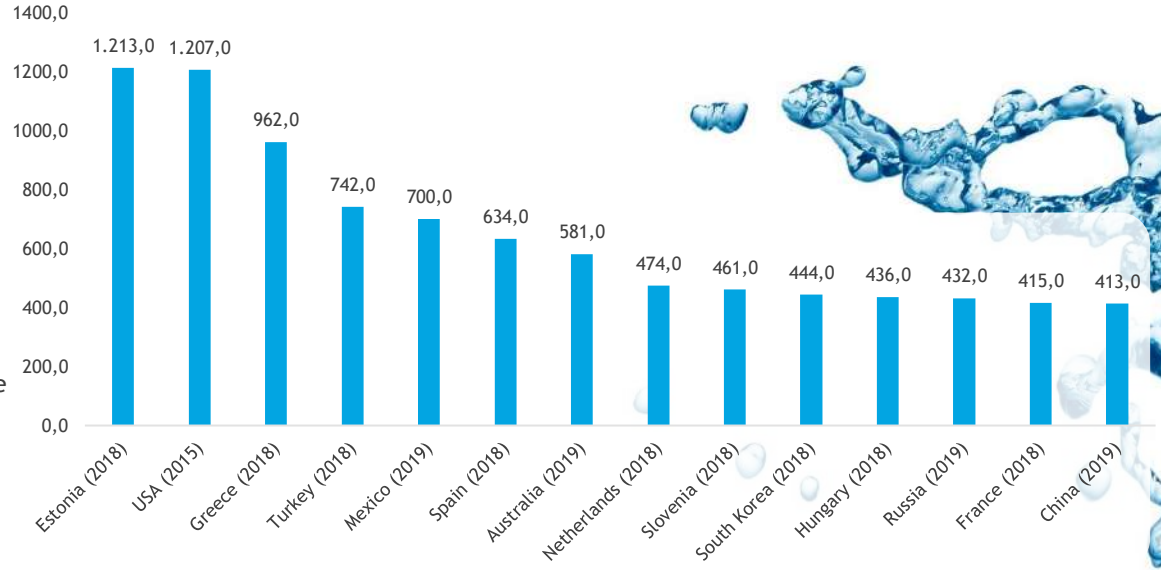
Notes: (1) Per latest available data; (2) Safely managed — use of improved facilities that are not shared with other households and where excreta are safely disposed; Basic — use of improved facilities that are not shared with other households; Limited — use of improved facilities that are shared with other households; Unimproved — use of pit latrines without a slab or platform, hanging latrines or bucket latrines; Open defecation — Disposal of human feces in fields, forests, bushes etc.

While Asia has the largest total water consumption, the water use per capita is the highest in the USA and Europe

Annual water withdrawals worldwide as of 2017, by region, in billion cubic kilometres per year



Annual water withdrawals per capita in selected countries, in cubic meters per inhabitant[1]

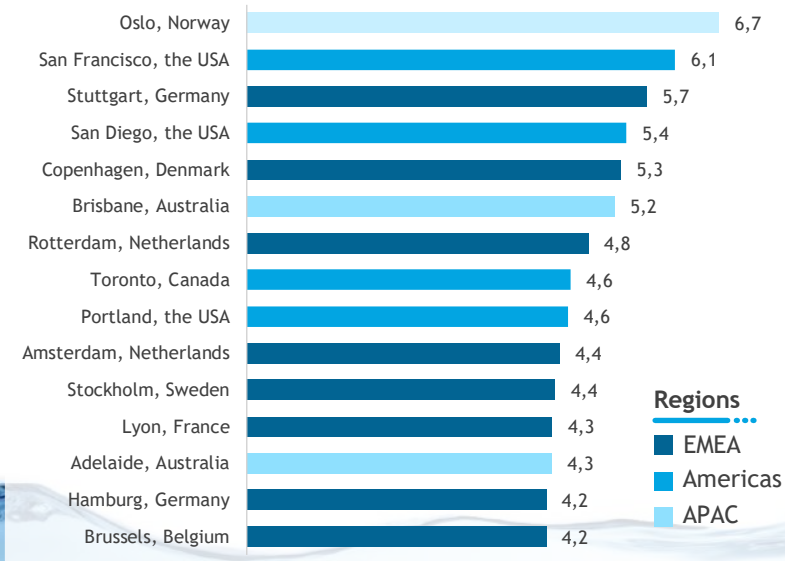


- Asia is currently home to **4,5 billion people**, who used **around 65,9%** of the world's water supply as of 2017
- On average, **144,0 litres of water per person per day** was supplied to households in Europe in the last decade
- **In Africa,** most people get **20,0 litres of water a day** which is the same quantity of water when having a shower for 1,5 minutes. Household water use averages **47,0 litres per person**
- The average **American household** uses **more than 1.000,0 litres of water per day**

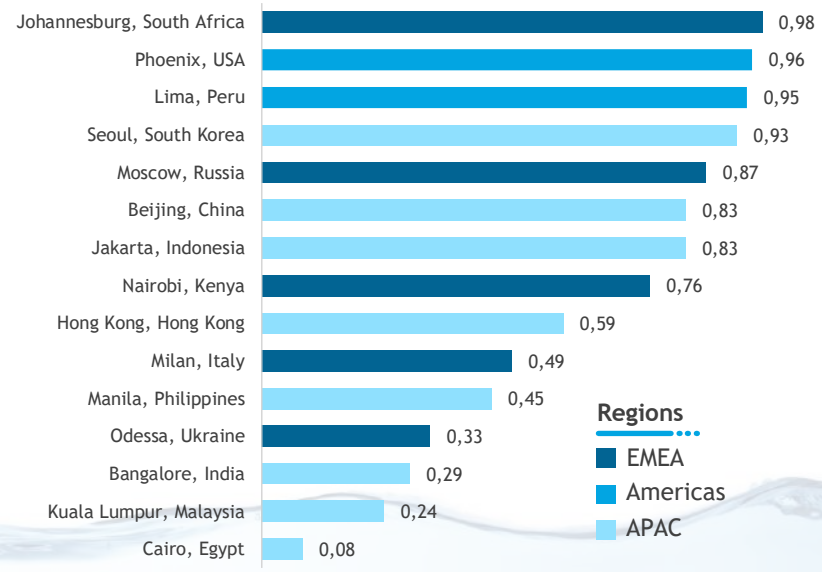
Source: Statista website, Media overview
Notes: (1) Latest available data

At the same time, the tap water supply in the US cities is offered at higher rates compared to other countries

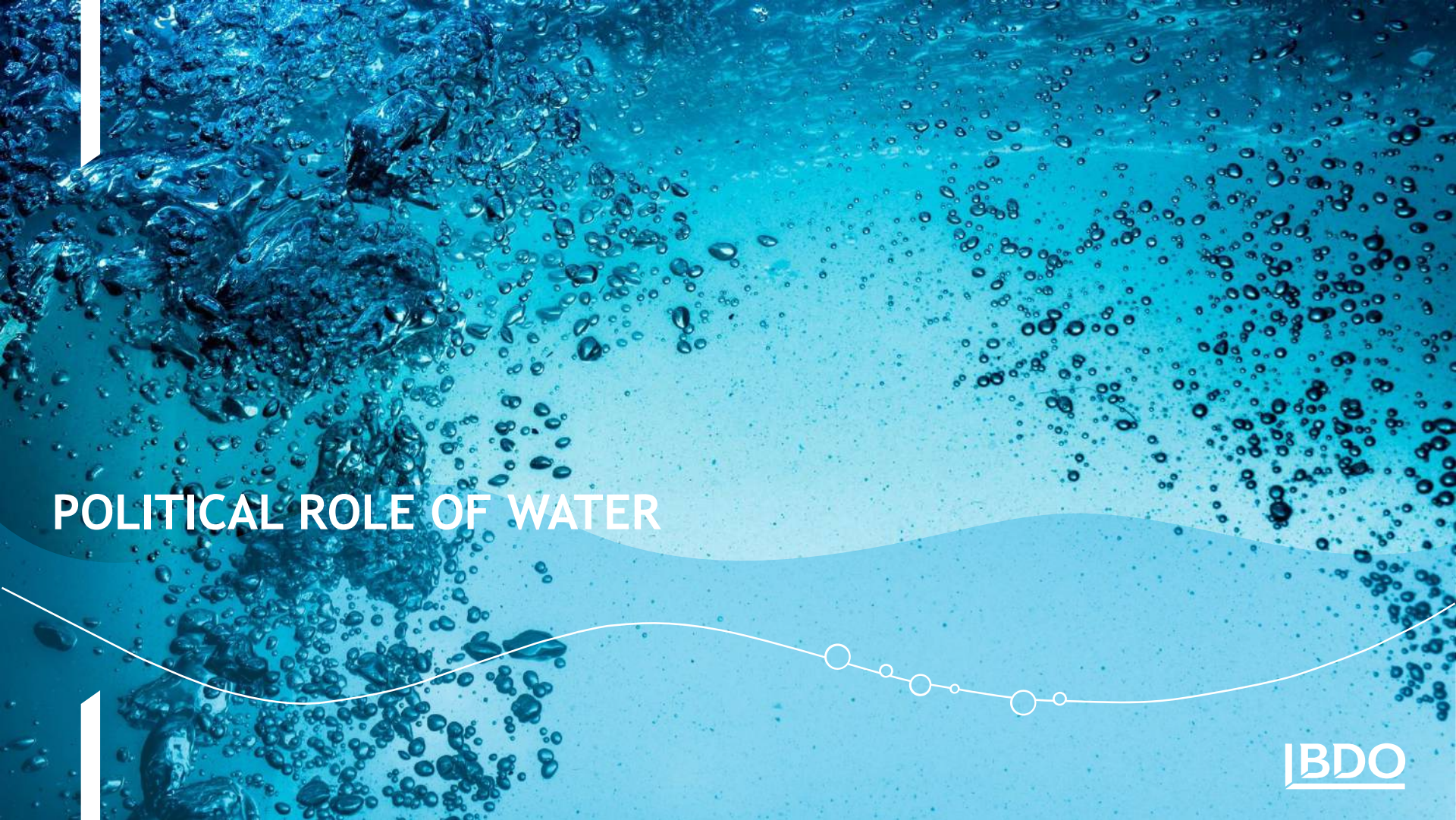
Most expensive prices of tap water in selected cities worldwide in 2021, in Euro per cubic metres



Lowest prices of tap water in selected cities worldwide in 2021, in Euro per cubic metres

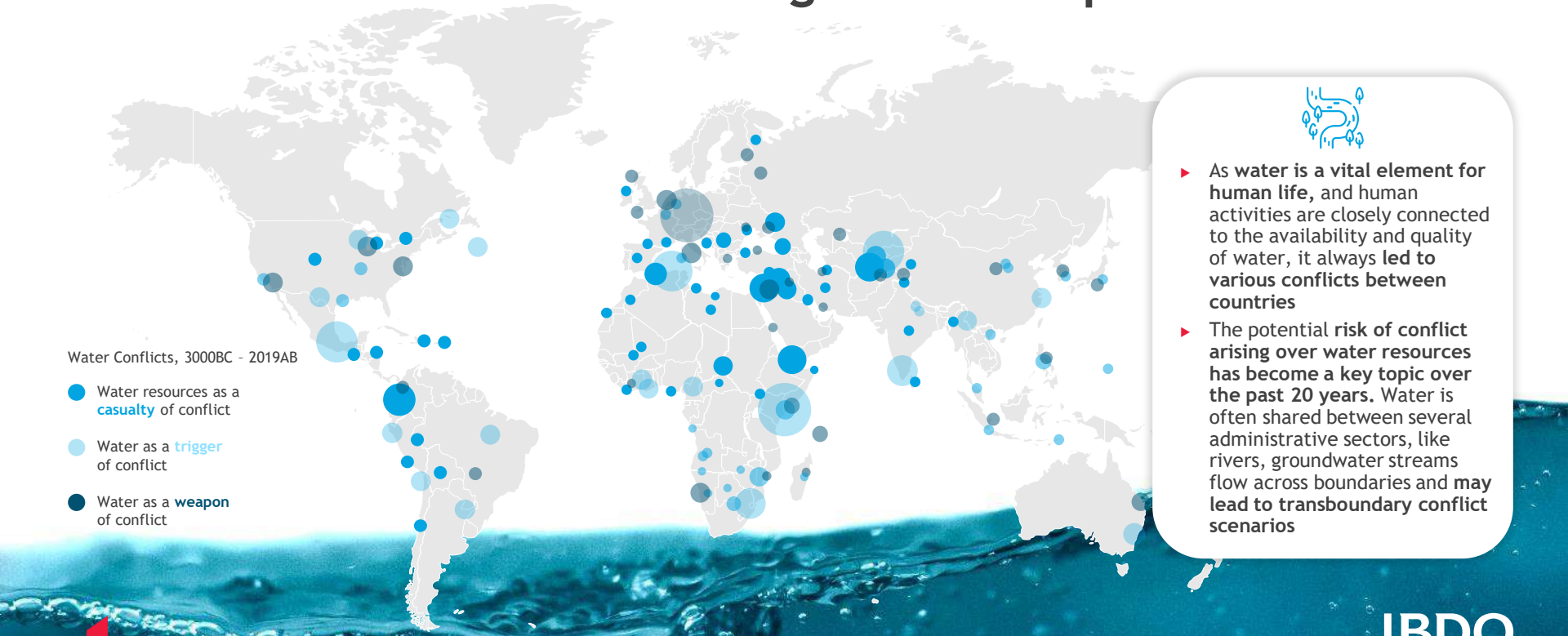


 Source: Statista website



POLITICAL ROLE OF WATER

The uneven water distribution on Earth and limited access to water resources in some regions cause political conflicts



- As **water is a vital element for human life,** and human activities are closely connected to the availability and quality of water, it always **led to various conflicts between countries**
- The potential **risk of conflict arising over water resources has become a key topic over the past 20 years.** Water is often shared between several administrative sectors, like rivers, groundwater streams flow across boundaries and **may lead to transboundary conflict scenarios**

Source: The Economist website; Media overview

The most recent geopolitical conflicts related to water resources were triggered by the dam-building projects

Dam building conflicts on Nile river

Counterparties

Ethiopia VS Egypt, Sudan

Causes of conflict

- Since 2011, **Ethiopia has been building a Grand Ethiopian Renaissance Dam (GERD)** on the Blue Nile, which makes **Egypt worried** that the dam might affect the overall flow of its biggest water source and waterway, **the Nile river**
- Together with the Nile downriver country **Sudan, Egypt brought the issue to the United Nations Security Council.** Countries' main concern is the risk of drought conditions such as those that occurred in the late 1970s and early 1980s. Thus, they **pushed Ethiopia to fill the reservoir over a longer period** if needed and **guarantee minimum flows**

Dam building conflicts on Mekong river

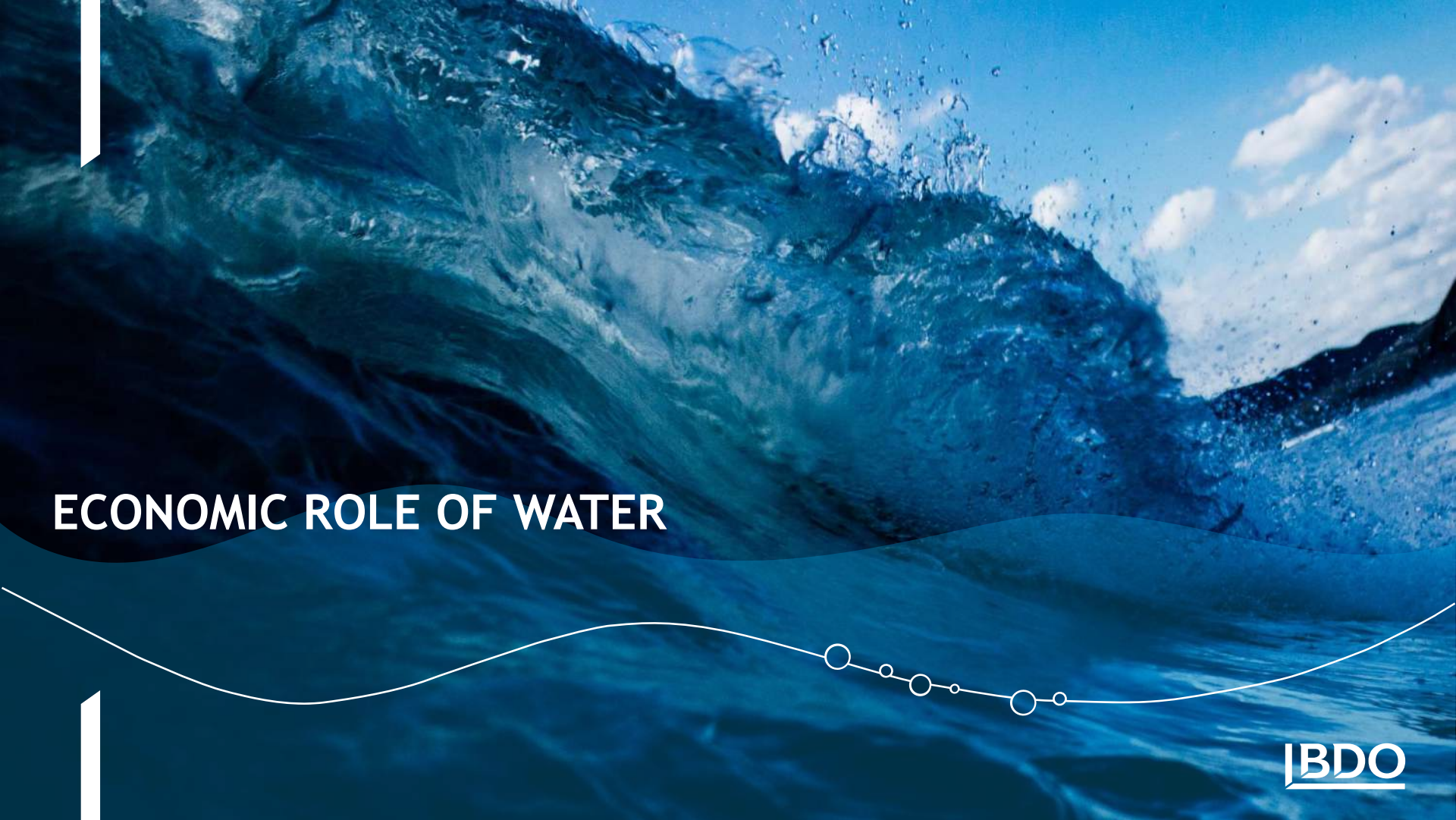
Counterparties

China, Laos VS Myanmar, Thailand, Vietnam

Causes of conflict

- **Mekong river** plays **an important role as a water and power supplier** to a number of Asian countries. Since 2010, **hundreds of hydropower dams have been built** up and down the river, mostly in **China and Laos**
- However, dam-building resulted in environmental destruction as **Thailand, Myanmar and Vietnam** regularly report **unusual flooding and droughts because of damming**
- International organisations **warn China and Laos against building new dams** and force them to abandon existing ones to **stabilise the situation in the region**

Source: Reuters website; China Dialogue website; Deutsche Welle website; Media overview


ECONOMIC ROLE OF WATER
BDO

Water as an essential resource for key business sectors plays a vital part in the global economic development

***Water plays a crucial role in the global economy**, as it is an essential input in all sectors. **Water scarcity can impact economic performance** through metrics such as GDP growth, trade balances, industry structure etc.*

Agricultural and Food Production

For global food production and security in the future, sustainable agricultural growth and efficient water use in the sector is needed.

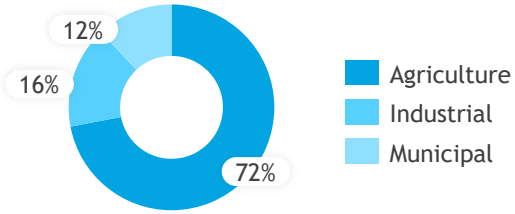
Industrial Development

For business development and economic growth, adequate access to water is required by many industries for smooth operations.

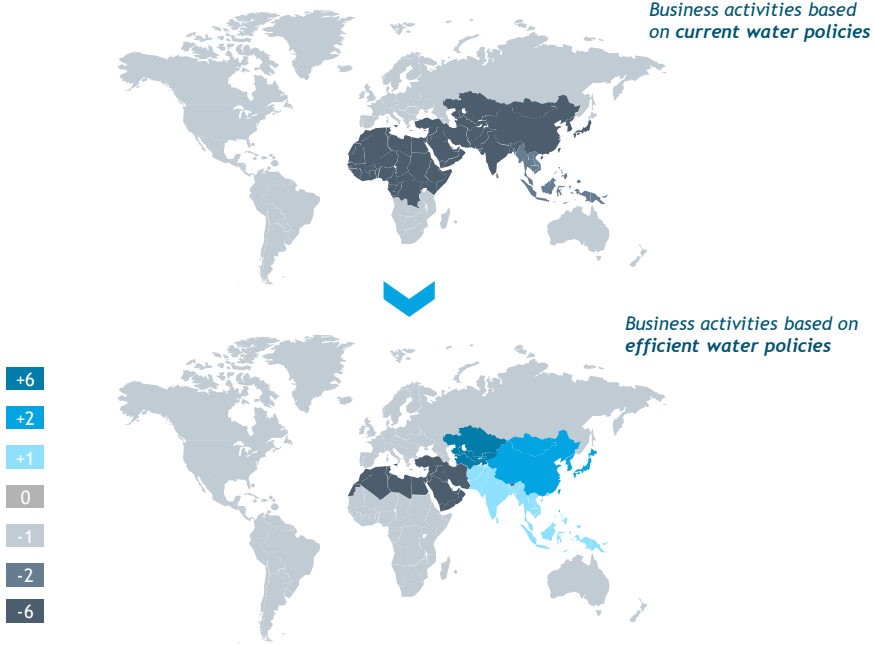
Water Storage Infrastructure

For secure water supply for households and businesses in the future, improved water storage capacity is a crucial component.

Global distribution of water withdrawals by sectors, 2017



Estimated effects of water scarcity on GDP in 2050[1]



Source: FAO website; World Bank website; OECD website; World Health Organisation website; UNESCO website
Notes: (1) For illustrative purposes

The importance of water use in value chains across different industries cannot be underestimated

Global water use has increased six times over the past 100 years and continues to grow steadily at a rate of about 1% per year with **increasing population, economic development and shifting consumption patterns.**

The OECD projected that water demand will increase by 55% globally by 2050, mainly as a function of **growing demands from manufacturing (+400%), thermal power generation (+140%) and domestic use (+130%).**

Evident importance of water use in various industries[1]

Agriculture

Agriculture as the largest using sector of water is **highly dependent on water supplies and increasingly subject to water risks.** Agricultural water is used for **irrigation, pesticide and fertiliser applications, crop cooling, and frost control.**

Energy

Water remains **fundamental throughout the lifecycle of energy infrastructure and resource development**, from extraction of raw materials, washing and treatment of raw materials to coolants in nuclear or thermal power plants to being a fuel for hydropower plants.

Industry

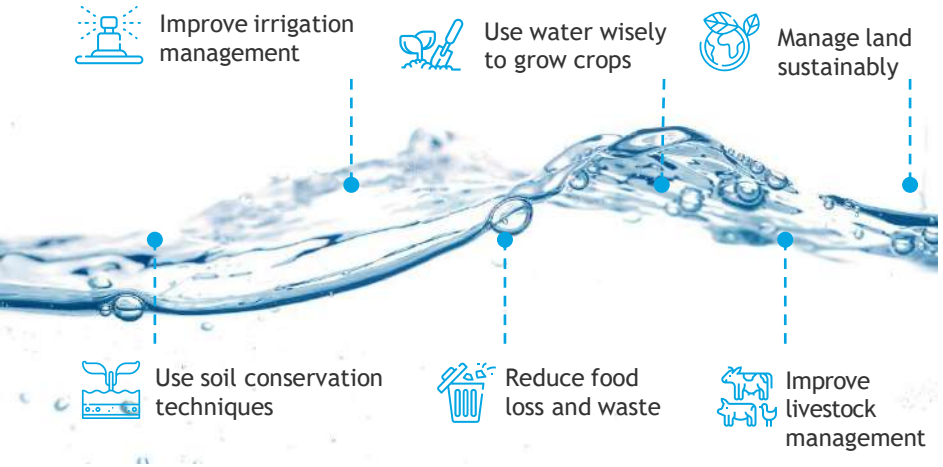
The industrial sector generally uses large amounts of water during their manufacturing processes. The industries with high water demand produce commodities such as **food, paper, chemicals, refined petroleum, primary metals etc.**

Source: UNESCO — UN Water Development Report 2020 — [2020]; FAO website; OECD website; World Bank website
Notes: (1) Water use in the domestic sector is analysed in Social Role of Water Section

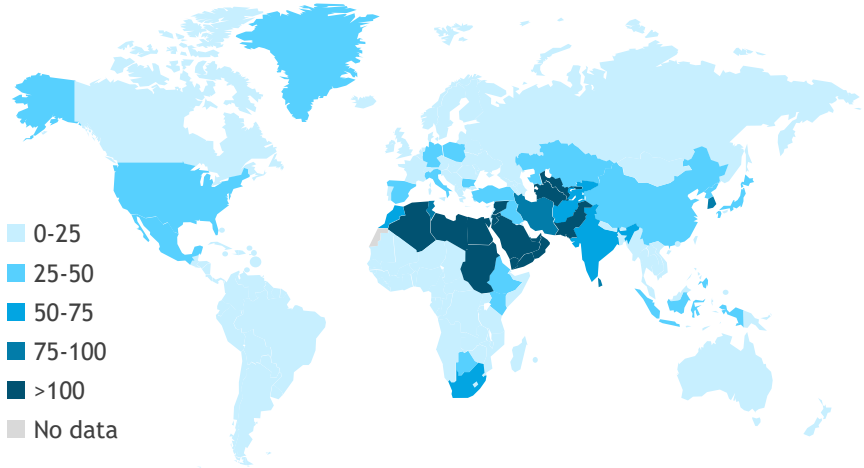
Agriculture industry remains the largest consumer of water causing a high stress on available water resources globally

Water is a critical input for agricultural production and plays an important role in food security. Irrigated agriculture remains the largest user of water, accounting for **70% of global water withdrawals** and **over 40% in many OECD countries**. Therefore, improving agriculture's water management is essential for **addressing water scarcity issues** and **managing high water stress locations.**

Key actions for sustainable agricultural water management



Level of water stress by country, 2018



Water stress is **the ratio between total freshwater withdrawals by major economic sectors and total renewable freshwater resources**, after taking into account environmental water requirements. The higher the number, the more water users are competing for limited supplies.

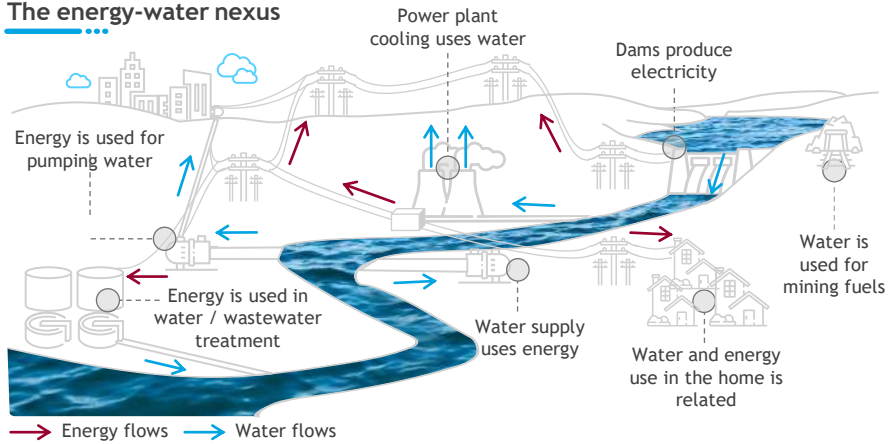
Source: FAO — World Food and Agriculture — Statistical Yearbook 2021 — [2021]; OECD website

The energy industry is exposed to increasing water risks, due to its strong water dependency in generation processes

Water is an integral element of energy-resource development and utilisation, as it is **used throughout energy production processes:**

- Hydropower
- Thermoelectric cooling
- Power plant operations
- Fuel extraction and refining
- Fuel production

The energy-water nexus



2,5 billion people have unreliable or no access to electricity

2,8 billion people live in areas of high water stress

By 2035, energy consumption will increase **35%**

Water consumption, as a result, will increase by **85%**

The energy sector accounts for more than **10% of global water consumption**, with **projected 60% increase by 2050**. Increasing demand for energy will continue to put significant pressure on global water resources **due to urbanisation, industrialisation and climate change:**

Water-related risks

- Water availability decrease
- Regulatory uncertainty
- Water quality
- Sea level rise
- Water temperatures increase

Possible solutions

- Integrate energy-water infrastructure
- Implement renewable energy technologies
- Incorporate water constraints into energy planning

Source: IEA website; UNESDOC website; EPA website; World Bank website

As water is widely used in different industries, the global action is required to secure future economic benefits

Water consumption across other industries

Oil & Gas Industry

The oil and gas industry requires **vast amounts of water across the value chain**, as the result it **negatively impacts water sustainability.** Some of **the most water-stressed regions** are also **the locations of intense oil and gas activity.** Even though, the industry disrupts water sustainability through its operations, it is also well-suited to manage water-related risks, as market players have required **engineering experience, construction capabilities and access to investment funds.**

Pulp & Paper Industry

The pulp and paper industry **is a large and growing portion of the world's economy.** Moreover, the production of pulp and paper is expected to increase in the near future. As a result, the **industry consumes huge amount of water, as it is used in almost every part of manufacturing process,** including **digesting wood chips, making fibre slurries, or washing rollers.** The main challenge for industry players is how to reduce the volume and toxicity of its industrial wastewater.

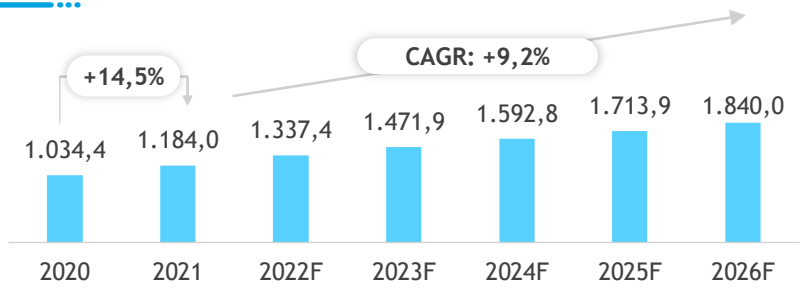
Food & Beverage Industry

The food and beverage industry **is one of the major contributors to the growth of all economies.** However, the sector has been associated with various environmental issues including **high levels of water consumption and wastewater production. For example, the bottled water segment appears to be highly competitive and profitable.** Yet, while it provides an access to clean water especially in the developing countries, it is also accused of being an additional source of waste.

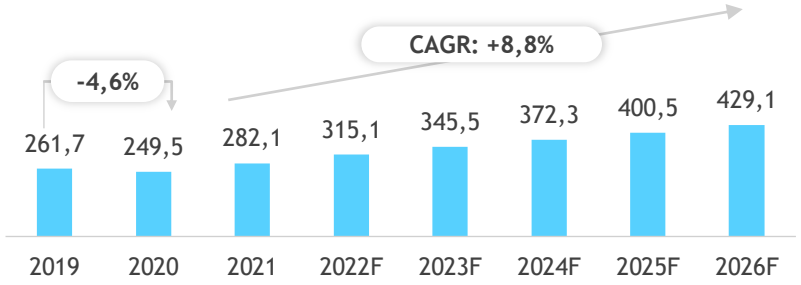
Source: World Bank website; OECD website; UN website

Water as an industry itself, including bottled water segment, is expected to grow in the coming years

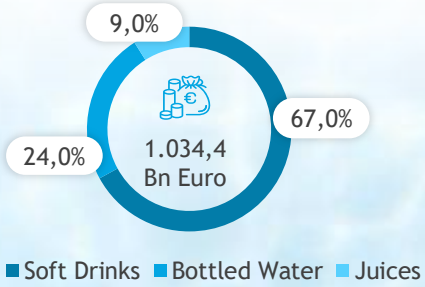
Global revenue of non-alcoholic beverages market, Bn Euro



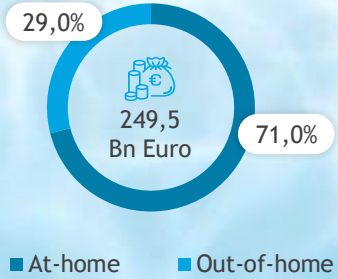
Global revenue of bottled water segment, Bn Euro



Global revenue distribution by type, 2020



Bottled water consumption by type, 2020

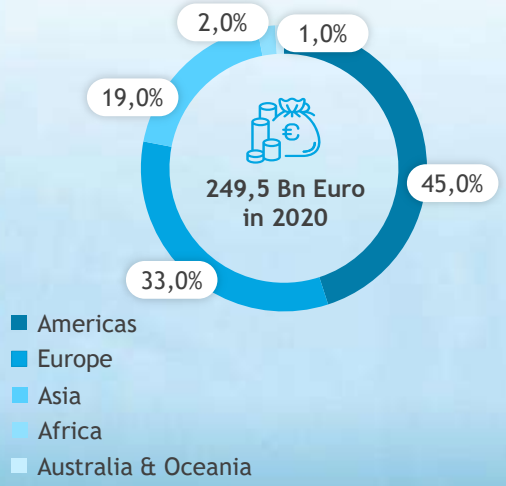


- **In 2020, the non-alcoholic beverages market generated total revenue of 1.034,4 Bn Euro worldwide. Key players** in the non-alcoholic beverages market are **PepsiCo, Inc., The Coca-Cola Co.,** Fomento Economico Mexicano SAB de CV, Coca-Cola Europacific Partners Plc, and Keurig Dr Pepper, Inc.
- In 2020, **the bottled water segment accounted for 24,0% market share** in the total non-alcoholic beverages market and its revenue amounted to 249,5 Bn Euro
- In the bottled water segment, **Switzerland and Germany had the highest annual revenue per capita in 2020** (98,1 Euro and 93,9 Euro respectively)

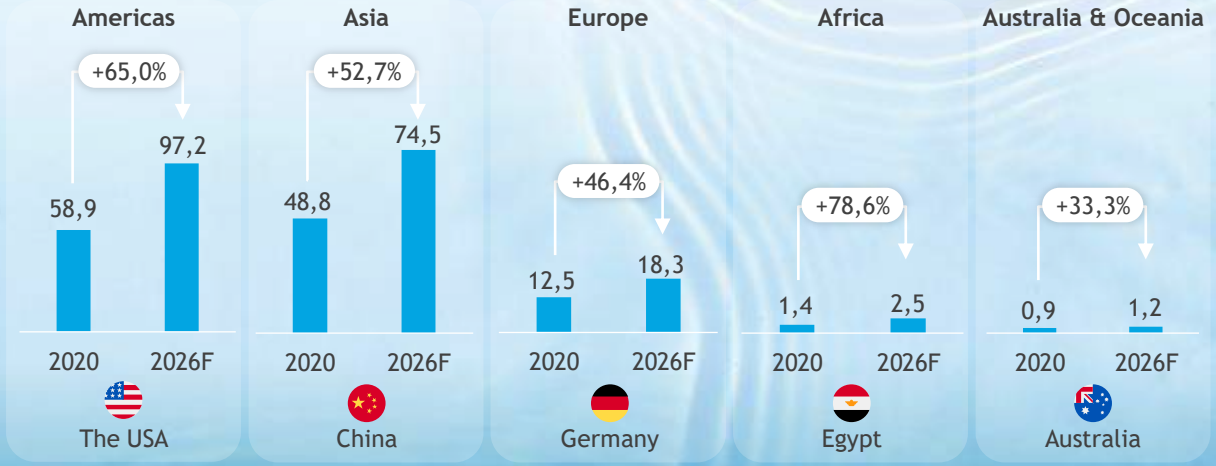
 Source: Statista — Bottled Water Report 2021 — [2021]

In 2020, the USA and China were the leading countries in terms of generated revenue in the bottled water segment

Distribution of bottled water revenue by regions



Top countries by revenue in the bottled water segment, Bn Euro

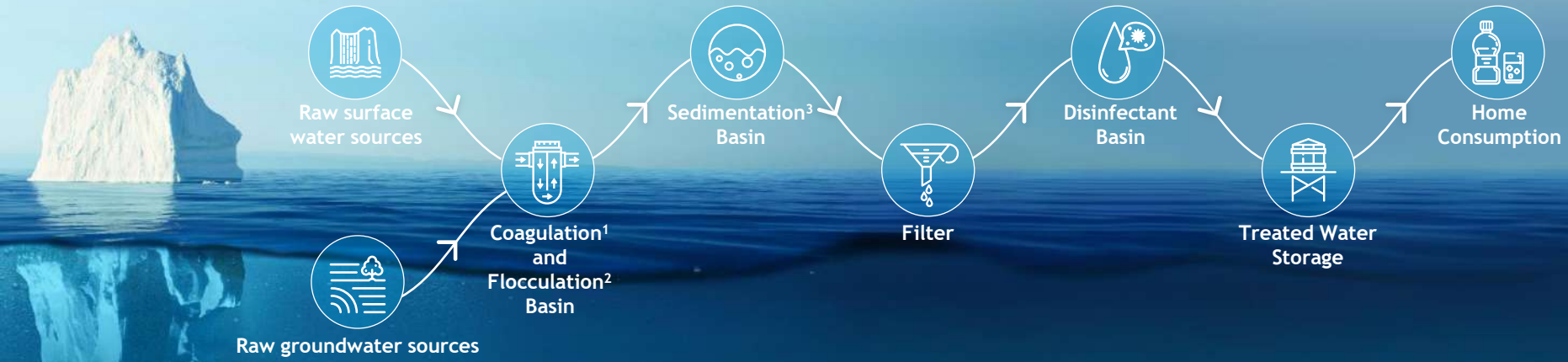


In 2020, the Americas was the leading region in the bottled water segment in terms of revenue. In 2020, the USA and China together accounted for 43,2% of revenue generated in the bottled water segment.

The revenues of the mentioned countries are forecasted to grow by more than 50,0% by 2026. In 2020, Aquafina, Dasani, Nestlé Waters, and Danone Waters were the leading companies in the bottled water market.

 Source: Statista — Bottled Water Report 2021 — [2021]

The purification of water in the bottled water production is a complex process that requires various resources



From source to consumption, water is purified during a large number of processes. Coagulation and flocculation are often the first stages of water treatment. During these stages, water becomes purified from such particles as sand, dirt, slime, softeners, lead, mercury iron, etc.

During sedimentation, floc settles to the bottom of the water supply, due to its weight. Once the floc has settled, the clear water on top will pass through filters to remove dust, parasites, bacteria, viruses, and chemicals.

After the water has been filtered, a disinfectant may be added to kill any remaining bacteria and to protect the water from germs when it is piped to homes and businesses. After mentioned stages, water is ready for consumption.

Water can have various flavours. Water's flavour depends on where the water comes from. Water bottled from mountain springs and wells can be packed with minerals that alter its flavour. Calcium makes water taste milky and smooth, magnesium makes it bitter, and sodium makes it salty.

Source: The Water Treatments website; Online Biology Notes website; Media overview
Notes: (1) Coagulation is the chemical water treatment process applied to remove solids from water, manipulating electrostatic charges of particles suspended in water; (2) Flocculation is the operation in which the coagulated water must be gently mixed at a propeller speed to promote the growth of the floc; (3) Sedimentation is a physical water treatment process applying gravity to remove suspended solids from water

Since the bottled water production causes environmental issues, leading companies develop sustainability initiatives

Aquafina is a brand of purified bottled water products. The company was founded in Wichita, Kansas in 1994. Aquafina is currently owned by PepsiCo, thus it has access to an extremely broad and efficient distribution network. Aquafina recognises the importance of sustainability issues and **to lessen the company's environmental footprint, the company has cut the size if their labels almost in half, producing 40% less plastic each year** and **has reduced the weight of packaging by 15%.**

Dasani, as a leading brand in the bottled water segment, applies its sustainability efforts and innovations to contribute to **'World Without Waste'** — an industry-first goal by Coca-Cola **to collect and recycle the equivalent of every bottle or can it sells globally by 2030**. Dasani with its global network of partners aims **to achieve the ambitious goal through the renewed focus on the entire packaging lifecycle.**

Nestlé Waters is one of the world's leading companies in the bottled water market, which is established in 130 countries**. Nestlé Waters supports the sustainable use of water** and strictly **controls its utilisation in the company's activities** for the responsible management of water resources. In 2000, Nestlé Waters first published **'The Nestlé Water Policy'** that confirms **the company's long-term commitment towards sustainable development.**

Danone Waters is a bottled water producer owned by Danone. The company's three biggest-selling bottled water brands are **Mizone, Aqua and Evian.** The company developed a new water sustainability strategy, which is called **'We Act For Water'.** This initiative brings together Danone Waters' brands including Volvic, Aqua, Evian, and **Bonafont to focus on responsible packaging, watershed preservation, climate neutrality, and global access to safe drinking water.**

 Source: Statista website; Companies' websites; Media overview

Various alternatives to plastic bottles are being developed by producers to decrease the environmental pollution

Alternatives to plastic packaging

Seaweed water bubbles

- The British startup Ooho has created **seaweed-derived capsules. These capsules biodegrade in less than six weeks and are edible.** They could be used in place of plastic bottles at events
- The manufacturing process generates **five times fewer CO_2 and uses nine times less energy** compared to PET[1] production. In the fourth year of development, the **production and delivery method of Ooho capsules are still being finalised**

Paper water bottles

- **Paper Water Bottles are designed to reduce the amount of plastic in the world.** This technology is redefining liquid packaging through the **innovative use of natural materials**
- A specially blended combination of bamboo and sugar cane provides a rigid outer shell. Paper water bottles are produced from **renewable and biodegradable materials** that can **convert to biogas for clean energy**

Plant-based plastic bottles

- **Bioplastic for plant-based plastic bottles are created from agricultural scraps, often from corn, sugarcane, wheat, or food waste.** Plant-based plastic bottles eliminate the need for oil resources while repurposing waste and benefiting from reduced carbon emissions
- **Another benefit is that plant plastics typically do not require pesticides** or chemicals to grow but is used bamboo fibre and wheat straw

Source: Media overview
Notes: (1) Polyethylene terephthalate

Reusable and recyclable water bottles are becoming more popular due to changing consumer preferences globally

Bottles from recyclable materials

Polycarbonate water bottles

- Bottled water companies use **polycarbonate plastic for their three- and five-gallon water cooler bottles.** Polycarbonate is transparent, lightweight and highly shatter-resistant
- Returnable polycarbonate three-and five-gallon bottled water containers are cleaned and sanitised between uses and **are reused 30 to 50 times before being recycled**

Cans water bottles

- **Aluminium is one of the most recycled materials.** Aluminium can be **recycled infinitely without losing quality or volume.** Due to **recycling, manufacturers save more than 90,0% of the energy** required to produce new metal
- There are a few brands of canned water, but **Open Water is the only one that is completely climate-neutral**

Glass water bottles

- **Outstanding bottled water companies choose glass as a packaging option for their premium bottled waters.** Among these companies are Evian, Acqua Panna, Voss, and Saratoga Spring Water
- **Bottles made out of glass are 100% recyclable.** Recycled glass is a part of the recipe for glass, and the more it is used, the less energy is needed to make it

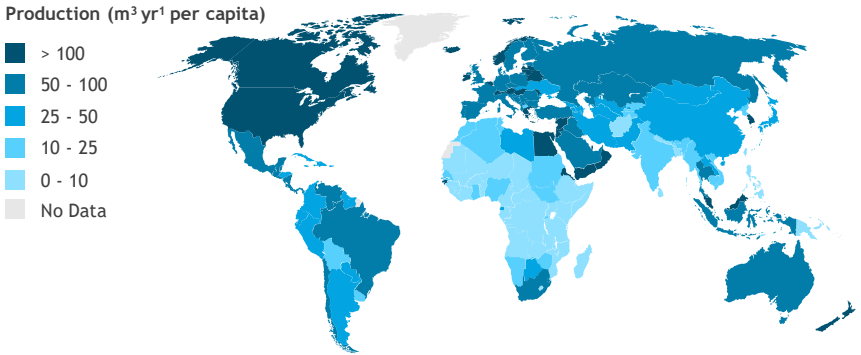
Source: Media overview

WATER POLLUTION AND WASTEWATER AS A PROBLEM OF HUMANITY

BDO

Water usage by households and industries produces large volume of wastewater, which becomes a global concern

Annual wastewater production per capita worldwide as of 2020



- In 2020, the global volume of wastewater production amounted to **359,4 billion cubic metres**, of which only about 62,8% was collected and nearly 52,6% was treated
- **The world average wastewater production per capita was 49,0 cubic meters in 2020**, which varied greatly across regions. **In North America**, the indicator was the highest (209,5 cubic meters), while **in Western Europe it accounted** for 91,7 cubic meters.
- In **sub-Saharan Africa** the average wastewater production per capita was **the lowest among other regions** and resulted in 11,0 cubic metres in 2020

Wastewater global key figures as of 2020, billion cubic metres

Annual collection **225,6** (62,8%[1])

Annual production **359,4**

Annual treatment **189,1** (52,6%[1])

Annual global average production: 49,0 cubic metres per capita

Types of wastewater or sewage

1. **Domestic wastewater** is the used water from households, is also called sanitary sewage
2. **Industrial wastewater** is the used water from manufacturing or chemical processes
3. **Storm sewage or storm water** is the runoff from precipitation that is collected in the pipe systems or open channels

Source: Earth System Science Data website; Statista website
Notes: (1) Share of all wastewater generated worldwide

As a solution, both domestic and industrial wastewater treatment will be increasingly in-demand in the future

Wastewater treatment methods

Domestic wastewater

Biological

Biological treatment comprises methods that **harness the action of bacteria and other microorganisms** to clean water from organic contaminants.

- Aerobic processes[1]
- Anaerobic processes[2]
- Composting[3]

Physical

Removes materials that will either **float or readily settle out by gravity.**

- Sedimentation[4]
- Aeration[5]
- Filtration

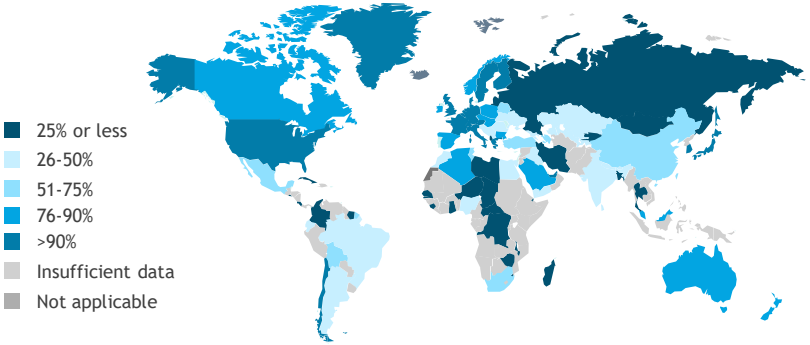
Industrial wastewater

Chemical

Chemical treatment of uses **chemical reactants** to break down pollutants. The hazardous waste could be completely breakdown into non-toxic gases or modified

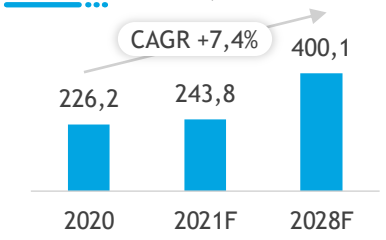
- Precipitation
- Neutralisation
- Disinfection

Proportion of domestic wastewater safely treated worldwide in 2020

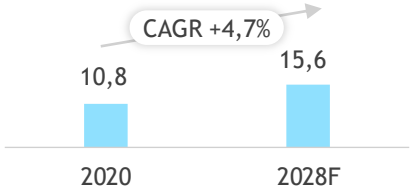


- Wastewater contains pollutants, which make water unsafe for human use. Pollutants vary depending on wastewater sources and could be treated by biological, physical or chemical methods
- There are **significant regional differences** in domestic wastewater treatment penetration. Approximately **80,0% of domestic wastewater is safely treated in North America and in the most of the European countries**, while less than 25,0% of wastewaters from households are treated in Central Asia and Africa
- The global water and wastewater treatment market size **is expected to grow at a CAGR of 7,4%** by 2028 reflecting the rising population and its access to water supply and sanitation facilities. The **industrial wastewater treatment market** size **is forecasted to grow by 44,4%** in 2028 compared to 2020

Global water and wastewater treatment market, Bn Euro[4]



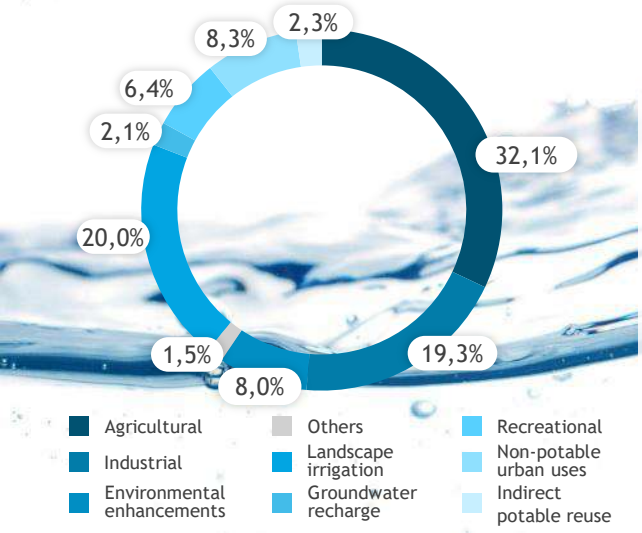
Global industrial wastewater treatment market, Bn Euro[4]



Source: UN Habitat and WHO — Progress on wastewater treatment — [2021]; Statista website; AOS Treatment Solutions website
Notes: (1) Biological process that uses oxygen to break down organic contaminants and other pollutants; (2) Biological process that breaks down organic contaminants in wastewater using microorganisms in the absence of oxygen.; (3) Mixing wastewater with carbon sources to convert into a humus-like product; (4) The numbers are converted from USD to EURO due to European Central Bank average exchange rate as of 2020

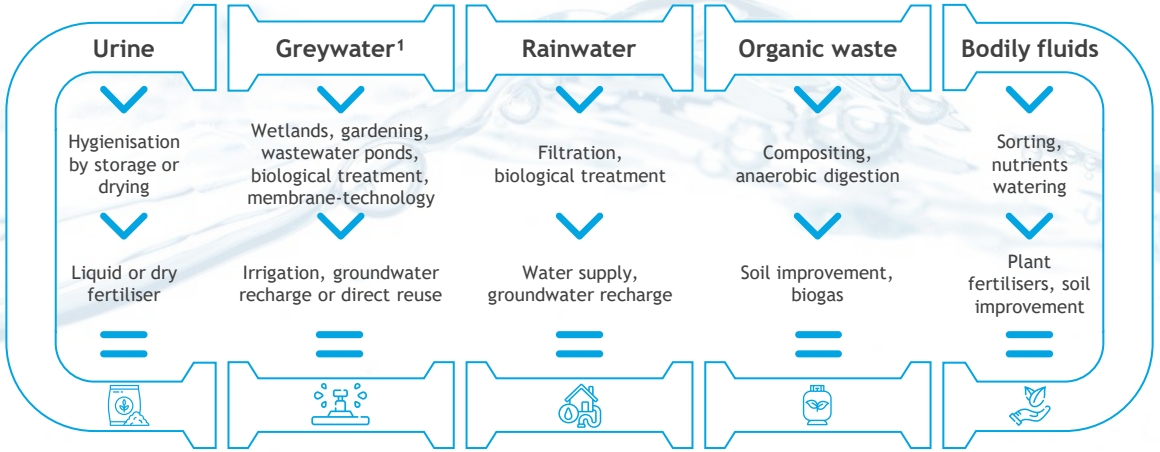
Reusing wastewater becomes an alternative water source for households and various industries around the world

Global wastewater reusage after advanced treatment, market share by application



Global treated wastewater reusage is estimated at **40,7 billion cubic metres per year**

Waste segregation and possible utilization options



More than **40.000,0 million cubic metres** of wastewater treated in EU every year

But only **964,0 million cubic metres** of this treated wastewater is reused

Source: UNESCO, Earth System Science Data, EU Website, The Down To Earth
Notes: (1) Wastewater from non-toilet plumbing systems such as hand basins, washing machines, showers and baths

TRENDS SHAPING THE WATER INDUSTRY

BDO

Current water management trends focus on more efficient water use and mitigation of environmental impact

Water management trends

Reusing water to support a circular economy

The **circular economy approach** to **reuse wastewater** could have **benefits for billions of people** as well as **climate advantages**. Of the 189,1 billion cubic metres of wastewater treated annually throughout the world, only 5% is reused at present. Reused water may **reduce the demand of agricultural, industrial, and potable sectors** on limited water sources.

Rising popularity of desalination

Desalination popularity is driven by **technological advances** that help make the **process costs and energy use** more efficient. Desalinated water might be a **sustainable way to replenish the water cycle** and could be a **climate change mitigating solution**. Desalinated water might be used in a **number of industries** as well as **consumed by people**.

Securing agricultural production

As the global population is projected to **reach more than nine billion people by 2050**, global food production needs to be **increased by 70,0%. Smart irrigation management, flood warning systems, and precision farming systems** might **optimise agricultural production** and **reduce the use of water**.

Getting access to quality data

Centralising and interconnecting all water-related data is crucial for many water utilities to **ensure effective decision-making. Totally autonomous control** over water treatment plants and **removing process fragmentation** might contribute to **the development of a modern efficient management model.**

Source: World Economic Forum website; Washington Post website; Media overview

Future water availability will be secured by the implementation of innovative technologies and solutions

Implementing smart and intelligent network technologies

Smart network technologies **enhance the reliability of physical water infrastructure** by **gathering and analysing data** more efficiently. **IoT[1], AI[2], Big Data**, and **remote water management** might **improve productivity and reduce water losses** across the whole water infrastructure.

Shifting focus towards sustainable approaches

Severe water shortages are driving the water industry to **develop recycling programmes** that **produce clean water.** Some governments are **introducing fines to discourage wasting water.** Companies develop innovative **consumer tools for saving water**, such as a **shower that saves more than 90,0% of water** by pumping it back from the drain and purifying.

Applying advanced filtration techniques

New filtration technologies are being developed and deployed **to meet the increasing demand for water** worldwide. Advanced filtration techniques **utilise graphene or other exotic materials** and **use modern technologies**, such as **carbon nanotubes and advanced membrane systems** that provide **greater efficiency for the water purification process**.

Increasing green hydrogen generation

Water is fundamental in **sustainable fuel generation, namely renewable hydrogen**. Green hydrogen is **emission-free and is less costly** than natural gas. Green hydrogen might provide **clean power** for numerous industries, including **manufacturing and transportation**. Water **plays a key role in the facilitation of general access** to this renewable fuel.

Source: World Economic Forum website; Media overview
Notes: (1) Internet of Things; (2) Artificial Intelligence

Desalination is one of the possible solutions to minimise impacts of water crisis and to ensure clean water access

What is desalination?

Filters **remove suspended solids and other particles** that would interfere with the desalting process.

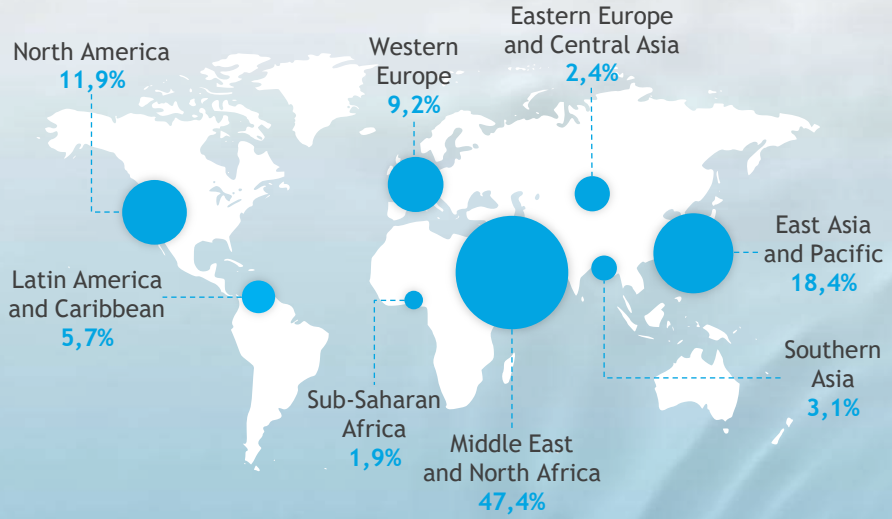
Reverse-osmosis membranes **separate dissolved minerals and other impurities** from the water.

Minerals and chemicals are added to ensure produced water meets **aesthetic and anti-corrosion standards.**

Desalination uses **reverse osmosis technology** to separate water molecules from seawater. Water from the ocean is **forced through thousands of tightly-wrapped, semipermeable membranes** under very high pressure. The membranes allow the smaller water molecules to **pass through**, **leaving salt and other impurities behind.**

Desalination capacity by region, as of 2020

Worldwide, there are currently **around 16.000 desalination plants** in more than **100 countries**. Collectively, they **can produce 95,0 million cubic metres of fresh water per day,** which is **enough to supply around 300,0 million people**.



Source: SDCWA website; Deutsche Welle website; Media overview

Smart water technologies allow households and industries reduce water usage and minimise water-related risks

Wide-spread usage of innovative technologies allows to **improve decision-making**, **enhance the efficiency of water infrastructure** and **protect people from the water-related risks. The World Bank**, along with **water innovation accelerator Imagine H_2O,** supports numerous **water technology businesses** that help **utilities serve customers digitally**, **solve water challenges globally** and **provide remote water resources management solutions**.

Selected solutions, supported by The World Bank and Imagine H_2O

Cloud to Street (United States)

Cloud to Street is a **flood mapping platform** that **detects worldwide floods** in real-time through **global satellites, machine learning and community intelligence.**

The platform combines data on **913 floods across 169 countries** to help scientists, governments, and financial institution **better prepare to risks of flooding.**

Ignitia (Sweden/Ghana)

Ignitia is a **tropical weather forecasting platform** with a **proprietary forecasting model** that predicts weather patterns and delivers **highly accurate, hyper-local forecasts** to small-scale farmers via SMS.

With Ignitia services, in 2019 **farmers reported up to 80,0% increase in income** due to decreased risks and losses.

Wonderkid (Kenya)

Wonderkid is a **software solutions company that provides services** for African water utilities and aims at **improving the quality** of their customer care and billing services.

Wonderkid solutions allow to **improve operational efficiency** of water utilities and result in the **revenue growth** as well as **transformation of water industry sector.**

Smarter Homes (India)

Smarter Homes is **smart metresing** and **automated leakage prevention system** for high-rise **apartment buildings in urban India.**

As of January 2022, **Smarter Homes** led to **35,3% reduction in water consumption** and **12,0% decrease in energy costs** of **communities with smart metress.**

Source: World Bank Blogs; Media overview

Businesses in various industries are increasingly implementing advanced technologies to improve efficiency

Innovative technologies such as **Internet of Things, Big Data, Artificial Intelligence (AI), and Blockchain**, originally embraced by the banking sector to increase the effectiveness of its business, are **actively adopted by the environmental and sustainable development sectors** to **improve resources' usage and management**.

Internet of things (IoT)

Internet-connected devices and sensors, from smartphones to networked manufacturing equipment, are able to **transmit to and receive complex data**. **Integrated systems** allow to **monitor, control, and regulate** the **usage and quality** of water resources, as well as **maintain the associated equipment.**

Big Data

Utilities and water companies are increasingly using **remote sensor technologies** to control and monitor pumping stations and water storage facilities. **Collected data** are used to **improve performance, detect problems, and optimise plant resource usage.**

Artificial intelligence (AI)

AI helps the water industry to become **digitalised** with **smart infrastructure solutions**. AI could **save up to 30,0% of the operational expenditures** by **reducing energy costs, optimising chemical use** for water treatment, and **ensuring proper asset maintenance**. AI might **predict emergency events and prevent water-related risks**.

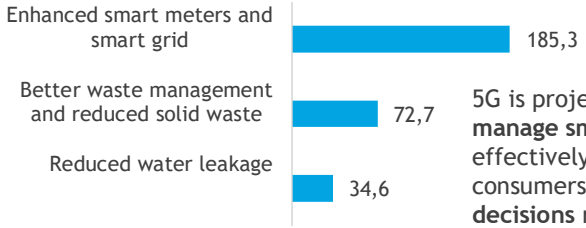
These three technologies go along a chain from the collection of data right through to its analysis. This is where **Blockchain** comes in.

Blockchain
Increasing usage of **sensors and Big Data technologies** encourage water utilities and water companies to **use secure blockchain systems** that **reduce risks of hacking, data destruction and improve the transparency of processes.**

Source: International Water Association website; Media overview

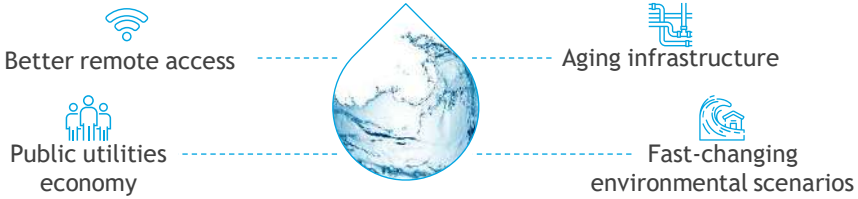
Moreover, digital solutions allow to transfer and receive data instantly to control water quality and manage leaks

Forecasted 5G applications contribution to productivity in smart utilities[1] management by 2030, by use case, in Bn Euro



5G is projected to **control and manage smart metress** more effectively, which will allow consumers to **make better-informed decisions** regarding water use.

5G technology could help solve main problems that water infrastructure currently faces



By 2025

half of the world population is forecasted to **live in water-stressed areas** that will need solutions for **preventing leaks** and **maintaining water quality**, as contaminated water is linked to **transmission of diseases**

5G

could deliver information about water quality and leaks **more quickly** and enable **remote** monitoring and control opportunities to help struggling communities **increase efficiency and lower costs**

How water infrastructure could benefit from implementing 5G?

- 5G can handle **up to millions of sensors per one square kilometre** ensuring the **connection of smart metress and devices on the streets and homes**. Some 5G features might **reduce battery consumption** that will **extend the lifetime of the sensors**
- **5G's improved security protocols** could contribute to increased **reliability of the water infrastructure** and **reduce the number of cyberattacks** that might interrupt the functioning of infrastructure and **cause significant losses**
- In the area of **wastewater**, **sewerage inspections** could be conducted **by drones driven via 5G in real-time** that will **enhance visibility in areas with difficult access**

Source: Statista; Media overview
Notes: (1) The companies in the electric, gas and water sectors that employ connected sensors across their grids in order to deliver services more efficiently and to analyse their operations

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