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Editorial: Water management addressing societal and climate change challenges

Water is the primary medium through which climate change influences the earth's ecosystem and thus people's livelihoods and well-being (IPCC 2014). Globally, 83% of all disasters have been caused by extreme weather and climate-related events, such as floods, storms, and heatwaves, over the past decade (IFRC 2020). Together, these disasters have killed more than 410,000 people and affected a staggering 1.7 billion people in different parts of the world (IFRC 2020). With a 50% increase in the global population and a 30% increase in the urban population from 2000 to 2050, the world will continue to face enormous challenges in most contexts. In many cases, poor people and developing countries are most likely to be affected.

The impacts of climate change will make the situation worse by creating extreme conditions with catastrophic outcomes. We may anticipate technological, economic, and sociological impacts resulting from climate change on water resources and processes.

The global average temperature has been increasing at a rate of 0.08 °C per decade since 1880. It has more than doubled since 1981 to 0.18 °C per decade (IPCC 2014). Recent studies predict a 5–15% rise in precipitation per centigrade degree increase in air temperature (Pfahl *et al.* 2017). Since 1901, global precipitation has increased at an average of 2.5 mm per decade. However, much higher increases and decreases in precipitation have been observed within continents, regions, and even countries.

In Europe, 200–400 mm per hour of rain has been observed, leading to devastating floods. They result in damage to infrastructure, water treatment processes, and increased pollution transport to recipients. While investing in separate sewers and stormwater pipes has started in many cities, this process is costly and slow.

Although rainwater is low in or free from pathogens, when rainfall increases runoff on the ground, it leads to increased microbiological pollution in raw water sources. This results from the mobilisation of pathogens in watershed discharges from centralised or decentralised wastewater systems and floods. The relative increase in *E. coli* bacteria could be several thousand times higher, while the increase in faecal streptococcus could be several tens of thousands of times higher (Kistemann *et al.* 2002). If the raw water source/catchment has pollution sources (environmental toxins, pesticides, heavy metals, etc.), this may increase transport to drinking water utilities.

Subsequently, this issue poses health risks associated with drinking water. Utilities will have to increase disinfection capacities in order to maintain adequate water quality. Increased turbidity and suspended solids in raw water also require increased particle removal processes, as they may interfere with disinfection processes.

Colour or natural organic matter (NOM) in raw water sources is common in many countries. It may produce harmful by-products during obligatory disinfection during water purification. A significant increase in NOM is observed in many sources, where climate change is a leading cause (Kritzberg *et al.* 2020). This increase requires removal processes to be strengthened with the adaptation of disinfection processes (Kastl *et al.* 2016; Valdivia-Garcia *et al.* 2019).

With less than 0.3% of all water available as fresh water for human use and unevenly distributed, many regions in the world face physical and economic water scarcity. At present, 47% of the global population, or 3.6 billion people, live in areas that suffer from water scarcity at least one month each year, which is expected to increase to 52% by 2050 (Mekonnen & Hoekstra 2016). A decrease in precipitation increases water scarcity challenges even in non-arid areas, where the demand already does not meet the supply. The droughts and reduced precipitation will also increase the use of severely limited groundwater, resulting in drying up or intrusion of saltwater in coastal belts. Saltwater intrusion is often a non-reversible process or may take many years to reverse. It will further worsen water scarcity, as the population in whole areas will suddenly lose access to fresh water.

By the late 21st century, the global land area and population facing extreme droughts could more than double, increasing from 3% in 1976–2005 to 7–8% (Pokhrel *et al.* 2021). Increasing temperatures can exacerbate existing drought conditions and impacts (ESCAP 2021).

The global mean sea level has risen about 19 cm since 1880 at an accelerating rate (Church & White 2011). From 2018 to 2019, the global sea level rose by 6.1 mm. Besides other natural forgings, the main reason is greenhouse effects, leading to a global temperature increase that melts ice layers and glaciers. Even if the world follows a low greenhouse gas pathway, the global sea level will likely rise by at least 30 cm by the year 2100, compared with the increase in 2000. However, the rising rate

is far from uniform between continents and regions (WMO 2021). Economic projections against climate models report a high magnitude of physical risks that 105 countries will experience in the next three decades (MGI 2020).

Climate change may also create positive impacts; there may be significant overall benefits to health and development in adapting to climate change. For example, efforts to adapt to climate change would create a stimulus to aim directly for higher service levels for those currently unserved. Increased awareness of water conservation measures may lead to less water wastage (BBC 2021). Concerns about adapting to climate change create substantial pressure to rationalise the choice of technologies for delivering sustainable and effective services (WHO 2010).

Sound water usage with reduced water consumption began in some cities several decades ago. Wastewater does not necessarily need to be reused as drinking water, but its use for industrial and agricultural purposes will help address the challenges in the drinking water supply. Although water reuse has also become a significant focus in Europe, it still has a long way to go. Systematic water reuse in Asia and Africa is seldom practised, while sporadic use of greywater for agriculture is done. However, domestic greywater reuse in agriculture must be carried out with caution to avoid food contamination.

Recent warnings from the UN on the *new pandemic* concerning Sustainable Development Goal (SDG) 6 – access to clean drinking water for all – have been expressed in a recently published report (UNDRR 2021). The importance of good water management is no longer something that concerns only the driest areas of the world but also major economies and some of the world's wealthiest regions. The Western United States and the city of Cape Town are but a few recent examples.

The monitoring of SDG 6 on clean water and sanitation shows only moderate improvements in, for example, Africa, where millions of people on the continent still practise open defaecation (SDR 2021). Sanitation is a huge challenge and has been identified by the African Union as one of the main African challenges in the years to come.

Climate change mitigation may have adverse socio-economic impacts. One of the most severe effects is migration to urban centres and towards the north to reach the Mediterranean and across Europe. Thousands of people have died en route to a better life in the north, and mitigating the impacts of climate change remains one of the most significant global challenges facing us in the years to come.

The adaptation to potential changes in the availability of water supplies because of climate change is estimated to be 9–11 billion USD per year in 2030. However, the total adaptation costs for managing increased flood risk, maintaining water quality standards, and supporting instream economic and environmental uses will increase to a staggering 32–40 billion USD annually (UNFCC 2007).

Climate change impacts have vast consequences in the water sector, increasing health risks, environmental pollution, and substantial economic impacts. While most water professionals are working on abatement and impact-minimising activities, it still does not look like all challenges will be solved in the near future. Sound medium- and long-term planning and firm political commitment will be required to minimise the negative consequences that mankind may face with climate change impacts.

There are numerous global, regional, and national initiatives to address the technical and socio-economic challenges associated with the impacts of climate change on water. The Water and Society project, involving four countries in Africa, three from Asia, and one from Europe (www.WaSoProject.org), is an example and has inspired this special issue, which presents some water management challenges in Asia and Africa resulting from climate change. Selected studies on changes in water quantities and their socio-economic impacts, as well as examples of abatement activities and their effects, illustrate the challenges involved, their status, and solutions.

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