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Climate change adaption in water engineering

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HYDRO-ENVIRONMENT > CLIMATE CHANGE ADAPTATION

Climate change adaptation in water engineering

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Climate change adaptation in water engineering

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Figure 1 | The Hondsbossche Dunes in the Netherlands, a soft natural barrier reinforcing a local sea dike.

Introduction

The community of professionals, stakeholders and end-users in the water engineering sector is concerned about the observed and projected impact of global warming and related changes (Masson Delmotte et al., 2018) on the water cycle. Little doubt exists about the fact that the observed global temperature increase is already impacting some components of the hydrosphere, the most evident one being the cryosphere with the retreat of ice masses. The Gravity Recovery and Climate Experiment (GRACE), launched by the United States National Aeronautics and Space Administration (NASA) and the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR) in 2002, is showing, for instance, that Greenland and Antarctica experienced ice mass changes of -281 Gigatons/year and -125 Gigatons/year, respectively, from 2002 to 2016 (NASA, 2018). Together this corresponds to a sea level rise of 11 cm/century which would increase considering the projected global warming in the forthcoming decades and the thermal expansion of ocean's water. However, the impact of climate change on annual runoff (Su et al., 2018) and on the intensity of floods around the world (Blöschl et al., 2018) is still unclear, in part because it is not easy to discriminate between the natural and anthropogenic forcing causing such changes. This indicates that we must rethink our approach to designing hydraulic structures and managing water resources in the most climate-sensitive environments, such as coasts and islands, mountain areas, fast developing mega-cities, and high-latitude tundra with permafrost.

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At the same time, we need to strengthen our scientific efforts in monitoring and understanding the impact of global warming on the water systems. This will also contribute to the effort to achieve the Sustainable Development Goals of Agenda 2030.

Updating design criteria of hydraulic structures including climate change scenarios

Funding agencies such as the World Bank Group (2019) and the Asian Development Bank (2013) request more and more frequently that climate change scenarios be included in the engineering design of large water projects. However, because of the uncertainty about how and to what extent global warming will impact several aspects of the water cycle, such as the intensity and timing of droughts and floods, the criteria for including non-stationarity in time series analyses must be further developed based on a consensus in the scientific and engineering community.

Hopefully this consensus can be reached soon. Design criteria that properly account for the effect of climate change should also be used to assess the resilience of hydraulic structures constructed in earlier times and to assess the need for upgrades or changes in their maintenance. Standards for the design of urban infrastructure need to be upgraded (CSA, 2012) and a balance has to be sought between 'hard' engineering, such as the Venice sea barriers, and 'soft' Building-with-Nature solutions such as the pioneering Delfland Sand Motor experiment (Figure 1) (Van Eekelen et al., 2019) and mangrove planting sites in Asia to protect coasts and sea dikes from the impact of sea level rise and storm surges.

Figure 2 | Millet growing in zai pits in Burkina Faso. Photo by Hamado Sawadogo in Motis, T., D'Aiuto C., Lingbeek B., Zai Pit System, Echo Community, Technical Note n.78, http://edn.link/tn-78, 2013.

Irrigation for sustainable water-efficient agriculture

In a changing climate, special attention must be paid to improving the efficiency in water use for agriculture. A recent IPCC report on climate change and land use (Shukla et al., 2019) pointed out with high confidence that all assessed future socio-economic pathways result in increases in water demand and exacerbate water scarcity. The same report recalls that solutions that help adapt to and mitigate climate change, and at the same time contribute to combating desertification, include irrigation techniques such as water harvesting and micro-irrigation.

Proper development of micro-irrigation with technology for remote control of the timing and quantity of water releases, supported by satellite monitoring or unmanned aerial vehicles and improved irrigation management not only would enhance the efficiency of water consumption and food security in water scarce landscapes, but would also contribute to maintaining the organic functions of the soil, thus combating desertification, storing carbon in the soil and mitigating the impact of climate change. In this sense irrigation needs to be framed in the more general context of sustainable agriculture, which, according to the FAO (2018), requires an ecosystemic approach that involves both farmers, the general public, communities and other stakeholders working together to increase landscape resilience (Figure 2). An efficient use of water at the global scale includes also virtual water trade (D'Odorico et al., 2019) as a key component of the water-food-energy-climate nexus which has strong implications on water and food security.

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It requires an ecosystemic approach that involves both farmers, the general public, communities and other stakeholders.

Nature-Based Solutions (NBS) for water to combat climatic change

IAHR focuses not only on up-to-date traditional 'grey' hydraulic engineering, but increasingly on 'green' environment-friendly designs, including Nature-Based Solutions (NBS), which are inspired and supported by nature and use, or mimic, natural processes to improve water management cost effectively (Figure 3).

NBS use ecosystem services that contribute to specific water management outcomes, and offer significant potential to address contemporary water management challenges across all sectors, particularly sustainable agriculture and sustainable cities (WWAP, 2018).

One example is the concept of 'sponge' cities that reduces the risks of extreme events and supports adaptation to climate change with infiltration trenches, riparian buffer strips, green roofs and green spaces (Hakimdavar et al., 2014). Restored wetlands, which were significantly reduced by human activity in the last century, can provide additional storage and safeguarded biodiversity, while enhancing aesthetic and recreational opportunities.

As pointed out in the United Nations World Water Development Report 2020 (WWAP, 2020), NBS also help mitigate climate change by improving sequestration of carbon through, for example, reforestation and the rehabilitation of soil organic carbon.

Figure 3 | River restoration in the Alps with Nature Based Solutions and Building with Nature concepts (courtesy of the Autonomous Province of Bolzano, Italy).

Closing thoughts

Many voices, especially those of international organizations like the United Nations, have brought increasing attention over the last few decades to the importance of water for the wellbeing of all people around the world and the future of all of forms of life on the planet. A recent report by the World Water Assessment Programme (WWAP, 2020) has highlighted the fact that climate change will exacerbate the challenges of addressing most current water issues. This calls for increased efforts by all water professionals, researchers and academics to redouble their efforts in identifying and predicting climate change impacts, developing mitigation and adaptation measures, informing policy makers and educating the public so they can all rise to the challenge.

Key issues in climate change adaptation in water engineering

- Assessment of the impact of global warming on the water cycle at regional scale.
- Consensus between scientists and professionals to upgrade design criteria including climate change scenarios.
- Blended advanced technologies and traditional irrigation systems for sustainable water-efficient agriculture.
- Combination of up-to-date traditional 'grey' engineering and 'green' Nature Based Solutions in coastal defence.
- Regenerating and planning green 'sponge' cities, more resilient to floods and heat waves.
- Virtual water trade and the water-food-energy-climate nexus.

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About IAHR

The International Association for Hydro-Environment Engineering and Research (IAHR), founded in 1935, is a non-profit, global, independent members-based organisation of engineers and water specialists working in fields related to the hydro-environmental sciences and their practical application. Activities range from river and maritime hydraulics to water resources development and ecohydraulics, through to ice engineering, hydro-informatics, flood risk management and continuing education and training.

IAHR stimulates and promotes both research and its application, and by so doing contributes to sustainable development, the optimisation of world water resources management and industrial flow processes. IAHR accomplishes its goals through a wide variety of member activities including working groups, congresses, specialty conferences, workshops and short courses, journals, monographs and proceedings.

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