HENRY
Hydraulic Engineering Repository

Ein Service der Bundesanstalt für Wasserbau

Article, Published Version

Ranzi, Roberto

Climate Change impact, adaptation and mitigation in the water sector: new hints from the IPCC AR6

Hydrolink

Verfügbar unter/Available at: https://hdl.handle.net/20.500.11970/110518

Vorgeschlagene Zitierweise/Suggested citation:
Ranzi, Roberto (2022): Climate Change impact, adaptation and mitigation in the water sector: new hints from the IPCC AR6. In: Hydrolink 2022/3. Madrid: International Association for Hydro-Environment Engineering and Research (IAHR). S. 68-71.
https://www.iahr.org/library/hydrolink?hid=472.

Standardnutzungsbedingungen/Terms of Use:

Die Dokumente in HENRY stehen unter der Creative Commons Lizenz CC BY 4.0, sofern keine abweichenden Nutzungsbedingungen getroffen wurden. Damit ist sowohl die kommerzielle Nutzung als auch das Teilen, die Weiterbearbeitung und Speicherung erlaubt. Das Verwenden und das Bearbeiten stehen unter der Bedingung der Namensnennung. Im Einzelfall kann eine restriktivere Lizenz gelten; dann gelten abweichend von den obigen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Documents in HENRY are made available under the Creative Commons License CC BY 4.0, if no other license is applicable. Under CC BY 4.0 commercial use and sharing, remixing, transforming, and building upon the material of the work is permitted. In some cases a different, more restrictive license may apply; if applicable the terms of the restrictive license will be binding.

Climate Change impact, adaptation and mitigation in the water sector: new hints from the IPCC AR6

By Roberto Ranzi

In August 2021 the Intergovernmental Panel on Climate Change (IPCC), during its 54th session finalized the first part of the Sixth Assessment Report (AR6), Climate Change 2021: The Physical Science Basis[1], prepared by Working Group I (WGI). Later, in spring 2022 also the reports of Working Group II (WGII)[2] and Working Group III (WGIII) on Impact, Adaptation and Vulnerability and on Mitigation were published on-line[3]. The full Working Group III report is published only in draft form, while the Summary for policymakers has been approved. The concern of scientists, media, and decision makers about the trends of warming, melting of ice sheets[4], rate of sea level rise and other impacts on the hydrosphere and the biosphere is very high.

The thousands of pages of the IPCC reports and their summaries for policymakers provide a sound basis for an up-to-date approach for the assessment of the impact, the design of adaptation and mitigation measures in water engineering, a topic of high interest for IAHR.

Some of the headline statements and the summary conclusions from the IPCC reports which have a high or at least medium level of consensus are of special interest for the water sector and are summarized in the following. Parts of these reports are cited verbatim in this article in order to convey accurately to the readers of Hydrolink the message of the IPCC.

The science basis and impact on the water sector

The current state of the climate

It is indisputable that human activities are causing climate change, making extreme climate events, including heat waves, heavy rainfall, and droughts, more frequent and severe.

- The likely range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C.

- Human influence is very likely the main driver of the global retreat of glaciers since the 1990s and the decrease in Arctic sea ice area between 1979–1988 and 2010–2019. However there has been no significant trend in Antarctic sea ice area from 1979 to 2020 due to regionally opposing trends and large internal variability.

- It can be stated with high confidence that global mean sea level increased by 0.20 [0.15 to 0.25] m between 1901 and 2018. The average rate of sea level rise was 1.3 [0.6 to 2.1] mm yr^{-1} between 1901 and 1971, increasing to 1.9 [0.8 to 2.9] mm yr^{-1} between 1971 and 2006, and further increasing to 3.7 [3.2 to 4.2] mm yr^{-1} between 2006 and 2018. Thermal expansion explained 50% of sea level rise during 1971–2018, while ice loss from glaciers contributed 22%, ice sheets 20% and changes in land water storage 8%.

- In 19 out of 45 macroregions of the world an increase of heavy precipitation (drawn from one to five days precipitation) is observed, in 8 of them a low agreement is reached on the type of change and in none of them a decrease is assessed.

- Increased adverse impacts of inland flooding and flood or storm induced damages in coastal areas are observed worldwide, especially in Asia, Australasia, North America and mountain regions.

- In 12 out of 45 macroregions of the world an increase of agricultural and ecological drought, due to increased land evapotranspiration, is observed, in 28 a low agreement is reached on the type of change and just in one of them a decrease is assessed.

Possible Climate Futures

A set of five new illustrative emissions scenarios (named SSPx-y 'Shared Socio-economic Pathway' differently from the Representative Concentration Pathways (RCPs) in the 5th Assessment Report) labelled with x=1,..5, with radiative forcing, y, set to y=1.9, 2.6, 4.5, 7.0 and 8.5 Wm^{-2}, is considered in AR6.

- In the mid term (2041-2060) and long term (2081-2100) the very likely range of mean *global surface temperature increase* compared to 1850-1900 ranges from 2.0°C to 2.4°C and 2.7°C to 4.4°C, respectively, according to the SSP3-4.5 and SSP5-8.5 scenarios.

- It is virtually certain that the Arctic will continue to warm more than the global surface, with high confidence above two times the rate of global warming. Additional warming is projected to further amplify *permafrost thawing,* and loss of *seasonal snow cover,* of *land ice* and of *Arctic sea ice* (high confidence). There is low confidence in the projected decrease of Antarctic sea ice.

- It is virtually certain that global *mean sea level will continue to rise* over the 21st century. Relative to 1995-2014, the likely (with medium confidence) global mean sea level rise by 2100 is 0.28-0.55 m under the very low GHG emissions scenario (SSP1-1.9), 0.44-0.76 m under the intermediate GHG emissions scenario (SSP2-4.5), and 0.63-1.01 m under the very high GHG emissions scenario (SSP5-8.5).

- *Precipitation* is projected to increase over high latitudes, the equatorial Pacific and parts of the monsoon regions, but decrease over parts of the subtropics and in limited areas of the tropics.

- Increases in frequency and intensity of *hydrological droughts* become larger with increasing global warming in some regions (medium confidence). There will be an increasing occurrence of some extreme events unprecedented in the observational record with additional global warming, even at 1.5°C of global warming.

- It is very likely that *heavy precipitation events* will intensify and become more frequent with additional global warming. At the global scale, extreme daily precipitation events, with return period of 10 years, are projected to intensify by about 7% for each 1°C of global warming (high confidence).

- There is strengthened evidence since AR5 that the global water cycle will continue to intensify as global temperatures rise (high confidence), with precipitation and *surface water flows* projected to become more variable over most land regions within seasons (high confidence) and from year to year (medium confidence).

- Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in carbon dioxide (CO_2) and other greenhouse gas emissions occur in the coming decades.

The IPCC AR6 report depicts scenarios consistent with, but, to some extent, even more severe than the AR5 and poses responsibilities to the decision makers on the active measures to be taken to mitigate the effect of the projected global warming.

The water engineering community including IAHR is also challenged in order to properly address at the regional and local scale the impact of combined climatic and anthropogenic changes in the water cycle and revise the design and management criteria in the water sector.

Adaptation measures

The WGII report focused on the transformation and system transitions in energy; land, ocean, coastal and freshwater ecosystems; urban, rural and infrastructure; and industry and society. Chapter 4 of the WGII Report is fully dedicated to impact and adaptation in the water sector.

Land ocean and ecosystem transition

IPCC recognizes with high confidence that adaptation to water-related risks and impacts is well documented. For inland flooding, combinations of non-structural measures like early warning systems and structural measures like levees have reduced loss of lives. Enhancing natural water retention, e.g., by restoring wetlands and rivers, land use planning such as no build zones or upstream forest management, can further reduce flood risk. On-farm water management, water storage, soil moisture conservation and irrigation are some of the most common adaptation responses and provide economic, institutional or ecological benefits and reduce vulnerability. Irrigation needs appropriate management to avoid potential adverse outcomes, which can include accelerated depletion of groundwater and other water sources and increased soil salinization. However, the effectiveness of most water-related adaptation options to reduce projected risks declines with increasing warming.

Small islands

Observed adaptation measures in small islands during drought events includes community water sharing, as well as using alternative water resources such as water purchased from private companies, desalination units or accessing deeper or new groundwater resources and rainwater harvesting.

Urban, rural and infrastructure transition

With medium confidence it is perceived that combined ecosystem-based and structural adaptation responses are being developed, and there is growing evidence of their potential to reduce adaptation costs and contribute to flood control, sanitation, water resources management, landslide prevention and coastal protection. Responses to ongoing sea level rise and land subsidence in low-lying coastal cities and settlements and small islands include protection, accommodation, advance and planned relocation. These responses are more effective if combined and/or sequenced, planned well ahead, aligned with sociocultural values and development priorities, and underpinned by inclusive community engagement processes. Coastal cities and settlements play a key role in moving toward higher climate resilient development, as almost 900 million people lived within the Low Elevation Coastal Zone, below 10 m of elevation above sea level in 2020. Therefore, these areas make key contributions to climate resilient development through their vital role in national economies.

Adaptation in the agricultural sector

Water-related adaptation in the agricultural sector makes up the majority of documented local, regional and global evidence of implemented adaptation. Water and soil conservation measures (e.g., reduced tillage, contour ridges or mulching) are frequently documented as adaptation responses to reduce water-related climate impacts in the agricultural sector. The use of non-conventional water sources, that is, desalinated and treated wastewater, is emerging as an important component of increasing water availability for agriculture. While desalination has a high potential in alleviating agricultural water stress in arid coastal regions, proper management and water quality standards for desalinated irrigation water are essential to ensure continued or increased crop productivity. In addition to the energy intensity, risks of desalinated water include lower mineral content, higher salinity, crop toxicity and soil sodicity. Similarly, wastewater reuse can be an important contribution to buffer against the increasing variability of water resources. However, wastewater use guidelines that ensure the adequate treatment to reduce adverse health and environmental outcomes due to pathogens or other chemical and organic contaminants are essential.

Energy system transition

Within energy system transitions, the most feasible adaptation options support infrastructure resilience, reliable power systems and efficient water use for existing and new energy generation systems. Energy generation diversification, including renewable energy resources and generation that can be decentralised depending on context (including wind and small scale hydroelectric) and demand side management can reduce vulnerabilities to climate change, especially in rural populations. Adaptations for hydropower are effective in most regions up to 1.5°C to 2°C, with decreasing effectiveness at higher levels of warming. Hydropower can also play a role in compensating for the intermittency of other renewable energies. E.g., integrating hydro, solar and wind power in energy generation strategies in the Grand Ethiopian Renaissance Dam can potentially deliver multiple benefits, including decarbonisation, compliance with environmental flow norms and reduce potential conflicts among Nile riparian countries[5].

Cross-cutting options

Effective adaptation options for water-borne diseases include improving access to potable water, reducing exposure of water and sanitation systems to flooding and extreme weather events, and improved early warning systems

Enabling climate resilient development

Structural vulnerabilities to climate change can be reduced through carefully designed and implemented legal, policy, and process interventions. This includes rights-based approaches that focus on capacity- building, meaningful participation of the most vulnerable groups, and their access to key resources, including financing, to reduce risk and adapt. Evidence shows that climate resilient development processes link scientific, Indigenous, local, practitioner and other forms of knowledge, and are more effective and sustainable because they are locally appropriate and lead to more legitimate, relevant and effective actions. Governance for climate resilient development is enabled by adequate and appropriate human and technological resources, information, capacities and finance.

Mitigation

The WGIII report about mitigation, focused primarily on GHG emissions and the energy sector. Only the Summary for Policymakers has been approved so far. The final draft of the full report is available online but cannot be cited yet. So only short hints, relevant for the IAHR community are reported here.

Sustainable urban planning and infrastructure design including green roofs and facades, networks of parks and open spaces, management of urban forests and wetlands, urban agriculture, and water-sensitive design can deliver both mitigation and adaptation benefits in settlements. These options can also reduce flood risks, pressure on urban sewer systems, urban heat island effects, and can deliver health benefits from reduced air pollution. There could also be trade-offs. For example, increasing urban density to reduce travel demand, could imply high vulnerability to heat waves and flooding.

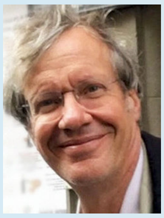
Electricity systems powered predominantly by renewables are becoming increasingly viable and in some countries and regions this is already happening. It will be more challenging to supply the entire energy system with renewable energy. Even though operational, technological, economic, regulatory, and social challenges remain, a variety of systemic solutions to accommodate large shares of renewables in the energy system have emerged. A broad portfolio of options such as, integrating systems, coupling sectors, energy storage, smart grids, demand- side management, sustainable biofuels, electrolytic hydrogen and derivatives, and others will ultimately be needed to accommodate large shares of renewables in energy systems. It has to be noted that IPCC considers the potential contribution of hydropower to net emission reduction relatively low, about 0.4 GtCO2-eq yr^{-1}, i.e. one tenth of that of solar or wind energy. However, hydropower is still the predominant source of renewable energy and accounts for about 16% share in global total electricity generation. Its potential of further development remains high but depends on the assessment of environmental and social impacts in the planning stages. Fundamental is the role of Pumped Hydroelectric Storage (PHS) which represents the largest fraction of electricity storage capacity globally.

Marine energy also has a high potential of development, some tens of PWh yr^{-1}, similar to that of hydropower, as energy can be extracted from tides, waves, ocean thermal energy conversion, currents, and salinity gradients.

The IPCC reports state with high confidence that restoration of mangroves and coastal wetlands sequester carbon, while also reducing coastal erosion and protecting against storm surges, thus, reducing the risks from sea level rise and extreme weather.

Concluding remarks

The huge amount of data, information, scenarios collected over ten years and presented in the almost 10,000 pages of the WGI, WGII and WGIII IPCC AR6 reports provides a sound basis for addressing the complex challenges posed by global warming, its impact on natural and anthropic systems and the adaptation measures to be taken to reduce the associated risks. The water sector is considered more mature than others but the potential of knowledge, technologies, solutions, developed in the hydro-community is fundamental to address such challenges. A multi-disciplinary approach paying attention to social, environmental, cultural, economic, communication aspects is needed to coordinate the efforts of professionals and researchers in the water sector in their contribution for the solution of the problems faced by the mankind in adapting to the multi-faceted changes triggered by the global warming.



Roberto Ranzi
PhD Roberto Ranzi is Professor of Hydraulic structures and River basin monitoring and restoration at the University of Brescia, Italy.

Professor Ranzi is Chair of the IAHR Technical Committee on Climate Change Adaptation.

http://roberto-ranzi.unibs.it

References

1 | IPCC, 2021: Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson- Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

2 | IPCC, 2022: Climate Change 2022: *Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA. 3056 pp., doi:10.1017/9781009325844.

3 | IPCC, 2022: Climate Change 2022: *Mitigation of Climate Change.* Summary for Policymakers. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. www.ipcc.ch

4 | Colosio, P., Tedesco, M., Ranzi, R., and Fettweis, X., 2021: Surface melting over the Greenland ice sheet derived from enhanced resolution passive microwave brightness temperatures (1979–2019), *The Cryosphere,* 15, 2623–2646, https://doi.org/10.5194/tc-15-2623-2021.

5 | Sterl, S., Fadly D., Liersch S., Koch H., and Thiery W., 2021: Linking solar and wind power in eastern Africa with operation of the Grand Ethiopian Renaissance Dam. *Nature Energy,* 6(4), 407– 418, doi:10.1038/s41560-021-00799-5.