Consensus statement from the Regional Action on Climate Change Symposium (RACC-15) held on September 30, 2023: An adjunct session of the Science, Technology and Society Forum (Kyoto).	

Critical hydrologic impacts from climate change: Addressing an urgent global need

An Accelerating Climate Crisis

This year the developing climate crisis has accelerated and worsened with further warming of both oceans and land. The overall threat continues to be driven by accumulating greenhouse gases in the atmosphere. This outcome has long been predicted by the climate science community.[1] But preparation for its impacts by policy makers and governments has been severely lacking.

Previously RACC warned: "Earth's climate, ecological and human systems could converge into a comprehensive crisis" worsened "by factors such as inequality, inadequate health infrastructure and food insecurity,"[2] as well as regional conflicts. Evidence of such convergence, sometimes now described as a 'polycrisis',[3] is now increasingly visible.

Whilst efforts to mitigate emissions remain crucial, we must now focus with equal commitment on supporting adaptation to these changes, especially for those most vulnerable.

A Transforming Hydrologic Cycle

Shifts in the hydrologic cycle are creating many of the most urgent needs for adaptation. Driven by climate change, these shifts threaten the availability of freshwater, impoverishment of biodiversity, reduced food production, and direct and indirect impacts on human health.

Traditional approaches to managing hydrologic variability are failing. Infrastructure, built for a climate system that no longer exists, is being overwhelmed by increasingly frequent and severe extreme events. Institutional

systems (such as insurance, fire fighting, disaster response, and organisations supporting displaced people) are increasingly unable to cope.

Governments find themselves unable to sufficiently reduce water withdrawals from stressed rivers (such as the Nile and the US Colorado River) and overtapped aquifers. Hydrologic variability is putting millions of people at risk. For example, in the Vietnamese Mekong Delta, increased variability is undermining hydropower and water infrastructure, whilst increasing farming costs and threatening livelihoods in both flooding and salinity zones.

Globally, rising temperatures, changing circulation patterns, and acidification of the oceans, combined with pollution and over-fishing, are disrupting the ocean's yield of marine foods with enormous potential impact for human populations.

Of particular concern are the impacts of hydrologic variability on those living in the drylands, and particularly those dependent on water supplies from the Himalayan regions where temperatures are rising fast and ice and snow are disappearing. This includes the 240 million people who live in the Hindu-Kush Himalaya mountains[4] - the “water tower for Asia” - which is the source of ten major river basins and the 1.9 billion people who live in them.

Fresh responses are needed. For example, more young leaders could be welcomed into training, capacity-building, research, advocacy, and policy-making. In the context of Future Design, where impacts on future generations are explicitly taken into account, [5] young leaders could play a much stronger role. Current road blocks to global agreement may be overcome by utilising experimental governance where policy innovation and potential solutions are first tried at smaller scales with successful outcomes building support for more comprehensive changes.[6]

Global commons such as the oceans need much greater research attention and protection through enhanced governance. The coastal regions, on which the food and livelihood of millions depends, are connected to one another by ocean currents, fish migration and floating pollutants. Equitable, globally shared responsibility in ocean governance, utilising best science for protecting all communities, is essential for averting the most serious impacts. Whilst a Special Report of the IPCC finalised in 2019 summarised current research,[7] together with the maritime biodiversity treaty adopted this year,[8] are good steps forward, much more globally coordinated work monitoring the ocean system and regional impacts needs to be established.

More immediately, energetic multidisciplinary development of adaptation strategies, able to address converging risks, should be supported. As a matter of priority these should be directed at building resilience of those who are most at risk.

Priority actions

From the local to global, actions are required now to prepare and protect the most vulnerable, especially in the drylands where some 80% of the Earth's poorest people live. Priority actions should be framed in the light of all SDG targets, including interlinked approaches to:

Monitor and predict threats and develop solutions for the most vulnerable and:

- Deploy early warning systems on the regional and local level.
- Develop technical approaches that can provide advance warning of major changes to the local climate system and their impacts.
- Focus on identifying and protecting human populations and ecosystems where climate impacts will be felt first and most intensely, including especially impacts on biodiversity and human health.
- Scale up the multiple benefits of research and development of nature-based solutions combined with agricultural, water, and food sufficiency measures that support SDG targets.
- Assist decision-making in the face of deep uncertainty using machine learning, behavioural science, non-market economics, and other methodologies.
- Devise and put in place updated infrastructure and institutions that address the converging impacts of extreme events.
- Support the enhancement of human coping and adaptive capacity in the most vulnerable ecosystems and societies.

Increase regional capacity and:

- Expand regional awareness of the threats of climate change and support access to action options.
- Research, publicize, and respond to the medical and mental health impacts of climate change.
- Improve private sector understanding and action on climate risks, especially in the insurance industry.

- Identify and publicize best practices in improving governance using multi-stakeholder engagement with local communities to enhance adaptation to climate risks.

Focus greater attention at all scales on a transforming hydrologic cycle and:

- Protect the hydrologic cycle as a "Global Public Common Good" with new economic policies and approaches that create greater value and incentive for more sustainable use of fresh water.
- Coordinate, support, and make visible at global scale, regional goals and efforts to protect and restore ocean sustainability as a global public good, and ensure research into ocean health is at a commensurate scale.
- Enhance efforts to adapt to shifting timing for drought, floods, and extreme weather conditions and optimize regional and international cooperation to address risks in countries facing rapid hydrologic changes.
- Encourage collaboration between policy makers, researchers, practitioners, and communities supported by knowledge-action networks, to discover and implement strategies for tackling the most serious risks in each place.
- Build global collaboration and capacity for disaster assistance sensitive to local needs and capabilities.

Focus and invest in science to transform agriculture to

- Develop greater water-use efficiency in agriculture (which represents some 70-80% of water withdrawals), including water re-use with cheap and effective methods to remove diverse contaminants from reclaimed water (for example, by utilising zero-valent sand filtration).[9]
- Support local food security by restoring currently declining soil health in many parts of the world using ecosystem and science-based approaches to return and retain carbon in soils, including financially rewarding carbon farming.
- Mobilise the biotechnology revolution to provide poor farmers with affordable drought and salt-tolerant seeds suitable to local agro-ecology under climate change. Continue development of genetic resources as a tool for adaption to dynamic increases of temperature.
- Support biodiversity in particular by bringing all UN systems dealing with biodiversity together and, with the CGIAR (Consultative Group for International Agricultural Research), coordinate and make the data openly available to vulnerable countries.

And, in particular:

- Build on the decision at COP-27 to redress loss and damage, by creating sufficient global funds and other supports including vulnerability indicators to identify, initiate, and finance urgent actions to ensure inter-generational equity and protect and support vulnerable populations as they face the converging threats of climate change.

In summary

Rapid and wide-ranging efforts need to be launched to support and improve community resilience to now unavoidable climate changes at all regional scales.

Efforts at mitigating greenhouse gases must accelerate in all sectors including agriculture, land use, and land use change and forestry, with restoration and conservation of ecosystems key to restoring the hydrologic cycle and water resources. But adaptation is no longer a secondary option. Governments at all levels need to anticipate converging threats and invest in economic, scientific, and policy responses. In particular, much greater and more urgent attention needs to be applied to the severe and escalating hydrologic impacts being driven by climate change, especially for the most vulnerable communities.

Needed actions include expanding access to local information about climate impacts, new financial investments and tools for local adaptation, education around both risks and adaptation strategies, global support to de-risk initiatives that invest in resilience where it is most needed, and provision of the resources to implement on-the-ground actions consistent with justice.

Current efforts are inadequate at all scales given the rapid rate of changes now occurring and the extensive and widespread risks. In particular, beginning at COP-28, it is vital that national leaders pledge to protect, resource, and support actions to help the most vulnerable populations, notably in the drylands, to build resilience to the mounting challenges of climate change.

The following contributed as co-authors to this statement:

- **Prof. Jim Falk** (RACC-15 Chair), Honorary Professorial Fellow, School of Geography, Earth and Atmospheric Sciences, University of Melbourne; Emeritus Professor, University of Wollongong, Australia.

- **Dr. Shinichiro Asayama** , Senior Researcher, Social Systems Division (Environmental Policy Section), National Institute for Environmental Studies (NIES), Japan.
- **Faten Attig-Bahar ,** Member of Steering Committee, Future Earth Water-Energy-Food Nexus Steering Committee; Member, Tunisia Polytechnic School, University of Carthage, Tunisia.
- **Dr. Swadin Behera** Director, Application Laboratory, JAMSTEC; Professor, Department of Ocean Technology, Policy, and Environment, University of Tokyo, Japan.
- **Prof. Joachim von Braun,** President, Pontifical Academy of Sciences, Vatican City State; Professor for Economic and Technological Change and Director, Center for Development Research (ZEF), Bonn University, Germany.
- **Prof. Rita R. Colwell**, Distinguished University Professor, Center for Bioinformatics and Computational Biology, University of Maryland College Park; Professor, Johns Hopkins Bloomberg School of Public Health, USA.
- **Dr Ashok K. Chapagain**, Senior Researcher,Pacific Institute, UK.
- **Prof. Adel S. El-Beltagy** Chair, International Dryland Development Commission (IDDC); Professor, Arid Land Agricultural Graduate Studies & Research Institute (ALARI), Ain Shams University, Egypt.
- **Dr. Peter H. Gleick**, President Emeritus, Pacific Institute for Studies in Development, Environment and Security, USA.
- **Prof. Charles F. Kennel**, Distinguished Professor and Director Emeritus, Scripps Institution of Oceanography, University of California, San Diego (UCSD); Distinguished Visiting Scholar, Centre for Science and Policy, University of Cambridge, UK.
- **Dr. Masahide Kimoto**, President of the National Institute for Environmental Studies; Professor Emeritus of the University of Tokyo, Japan.
- **Dr. Toshio Koike,** Executive Director, International Centre for Water Hazard and Risk Management (ICHARM), Public Works Research Institute, Japan; Professor Emeritus of the University of Tokyo.
- **Agnes Asiimwe Konde** Vice President, Program Development & Delivery, Alliance for a Green Revolution in Africa (AGRA), Kenya.

- **Prof. Phoebe Koundouri**, Department of International & European Economic Studies, Athens University of Economics and Business & Technical University of Denmark, Greece; President, European Association of Environmental and Resource Economists; Chair of the SDSN Global Climate Hub, Italy.
- **Dr. Sameh Kotb Mohamed Abd-Elmabod,** Associate Professor, Soils and Water Use Department, Agricultural and Biological Research Institute, National Research Centre (NRC), Egypt; Visiting Professor, Xinjiang Institute of Ecology and Geography (XIEG), Chinese Academy of Sciences (CAS), China.
- **Prof. Rattan Lal**, Distinguished University Professor of Soil Science, The Ohio State University, USA.
- **Prof. Yuan Tseh Lee**, President Emeritus, Academia Sinica [Nobel Laureate in Chemistry 1986], Taiwan.
- **Prof. Cherry A. Murray**, Deputy Director for Research, Biosphere2 and Professor of Physics, University of Arizona; Benjamin Peirce Professor of Technology and Public Policy and Professor of Physics, Emerita, Harvard University, U.S.A.
- **Dr. Vina Nangia,** Research Leader, Soil, Water, and Agronomy, ICARDA: International Center for Agricultural Research in the Dry Areas, Morocco; Professor, International Platform for Dryland Research and Education, Tottori University, Japan.
- **Prof. Amy Sapkota** , Professor & Director, Maryland Institute for Applied Environmental Health; Director, CONSERVE Center of Excellence; Director, Global Future Alliance, University of Maryland School of Public Health, USA.
- **Prof. Tatsuyoshi Saijo**, Professor, Institute for International Academic Research, Kyoto University of Advanced Science; Director, Future Design, Japan.
- **Dr Ismail Serageldin**, Founding Director Emeritus, The Library of Alexandria, Egypt.
- **Dr. Jean-François Soussana,** Vice President, National Research Institute for Agriculture, Food, and Environment (INRAE), France.
- **Prof. Kaoru Takara ,** President, National Research Institute for Earth Science and Disaster Resilience (NIED); Professor Emeritus, Kyoto University, Japan

- **Prof. Kazuhiko Takeuchi**, President, Institute for Global Environmental Strategies (IGES); Project Professor, Institute for Future Initiatives (IFI), The University of Tokyo, Japan.
- **Dr Thong Tran**, Research Fellow, School of Geography, Earth and Atmospheric Sciences, Faculty of Science, The University of Melbourne, Victoria, Australia; and Health and Agricultural Policy Research Institute, University of Economics HCMC, 279 Nguyen Tri Phuong, District 10, 72406, Ho Chi Minh City, Vietnam
- **Prof. David Victor**, Professor, Innovation and Public Policy; Co-director, Deep Decarbonization Initiative, University of California, San Diego, USA.
- **Dr. Chiho Watanabe**, Dean, Interfaculty Initiative in Planetary Health, Nagasaki University; former President, National Institute for Environmental Studies (NIES), Japan.
- **Dr. Kevin Wheeler,** Senior Research Fellow, Environmental Change Institute, University of Oxford, U.K.; Principal, Water Balance Consulting, U.S.A.
- **Prof. Tetsuzo Yasunari**, Senior Advisor and Professor Emeritus (former Director General) of Research Institute for Humanity and Nature (RIHN), Kyoto; Director of Kyoto Climate Change Adaptation Center (KCCAC), Japan.

More details of the RACC and its International Advisory Committee are set out at https://www.stsforum.org/racc2023/iac/.

[1] IPCC (2021), Masson-Delmotte V, Zhai P, Pirani A, Connors SL, Péan C, Berger S, Caud N, Chen Y, Goldfarb L, Gomis MI, Huang M, Leitzell K, Lonnoy E, Matthews JBR, Maycock TK, Waterfield T, Yelekçi O, Yu R, Zhou B, Climate change 2021: The physical science basis contribution of working group I to the Sixth Assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge

[2] Falk J., Colwell, R. R., Kennel, C. F., and Murray, C. A. (2021), Nature 599, 372. doi: https://doi.org/10.1038/d41586-021-03419-0

[3] Lähde, V. (2023) "The polycrisis", aeon, https://aeon.co/essays/the-case-for-polycrisis-as-a-keyword-of-our-interconnected-times

[4] Including the Krakoram mountains: Wester, P., Mishra, A. , Mukherji, A. , Shrestha, A. B. eds (2019), The Hindu Kush Himalaya Assessment: Mountains, Climate Change, Sustainability and People , Springer Nature Switzerland AG, Cha.

[5] Saijo, T. (2020). ”Future design: Bequeathing sustainable natural environments and sustainable societies to future generations.”, Sustainability, 12(16), 6467.

[6] Sabel, F. C, Victor, D. G. (2022). Fixing the Climate: Strategies for an Uncertain World, Princeton University Press, US and UK. ISBN: 9780691224558

[7] IPCC (2019), IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, 755 pp. https://doi.org/10.1017/9781009157964.

[8] United Nations (2023), General Assembly resolution 77/321 ,"Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction" adopted on 1 August 2023. https://www.un.org/bbnj/

[9] Seongyun, K., Eckart, K., Sabet, S., Chiu, P. C., Sapkota, A. R., Handy, E. T., East, C. L., Kniel, K. E., and Sharma, M.. (2021). "Escherichia coli Reduction in Water by Zero-Valent Iron–Sand Filtration Is Based on Water Quality Parameters", Water, 13, no. 19: 2702. https://doi.org/10.3390/w13192702