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Némedi Nándor[1]

DIFFERENT PERSPECTIVES ON THE RESPONSES TO THE CLIMATE CHANGE IMPACTS AND WATER SECURITY

(AZ ÉGHAJLATVÁLTOZÁS HATÁSAI ÉS A VÍZBIZTONSÁG KÜLÖNBÖZŐ PERSPEKTÍVÁI)

Absztrakt:

Climate change is likely to have a large impact on water management. For example, there is a need to reconsider the assumption of stationarity in climate and hydrology. The assumption of stationarity implies that the long-term variability in water resources availability (including precipitation, evaporation and run-off) remains between historical boundaries. However, under climate change, key climate and hydrological variables will change, as will water demand. The magnitude of the expected changes in climatic and hydrological variables is temporally and spatially uncertain. Their uncertainty poses a set of new and additional challenges for water managers on how to cope with these uncertainties in planning, design and operations to enhance future water security. Although climate change information has improved over the last decades and many impact studies have been carried out, water managers still struggle with how to cope with the impacts of climate change.

The author reflects of this article, mainly is to description of the main impacts of climate change on water and the needs for adaptation. Subsequently, different perspectives on the responses to the impacts are discussed. These perspectives include a section on the need to cope with the climate change impacts, paying special attention to decision-making processes and the need for improved economics. The next perspective presents and discusses the dialogue process that raised attention to water-related climate adaptation under the UN Framework Convention on Climate Change (UNFCCC) negotiations. Through these different perspectives this article introduces the broad-ranging playing field for water security and climate change.

Keywords: *climate change, economy, impacts, perspectives, water security.*

Az éghajlatváltozásnak várhatóan jelentős hatása lesz a vízbiztonságra. Például szükség van a klimatikus és hidrológiai stacionaritás elméletek újragondolására. A stacionaritás elmélet szerint a vízkészletek hosszú távú rendelkezésre állása (beleértve a csapadékot, a párolgást és az elszivárgást) történeti kereteken belül állandó. Mindazonáltal az éghajlatváltozás hatásaként a fő klimatikus és hidrológiai változók megváltoznak, ahogyan a vízszükséglet is. A várt klimatikus és hidrológiai változások magnitudója mind időben, mind térben bizonytalan. Ezek bizonytalansága új és további kihívások sorát jelenti a vízügyi mérnököknek, hogy hogyan kerekedjenek felül ezeken a bizonytalanságokon a tervezés, a kialakítás és a működtetés során a vízbiztonság növelése érdekében. Habár az elmúlt évtizedekben az éghajlatváltozással kapcsolatos információk bővültek és számos hatástanulmány készült, a vízügyi mérnökök még mindig küzdenek azzal, hogyan válaszoljanak az éghajlatváltozás kihívásaira.

[1] Nemzeti Közszolgálati Egyetem, Katonai Műszaki Doktori Iskola, doktorandusz. E-mail: nandee@t-online.hu, ORCID: 0000-0003-3175-5644

A szerző fő célja a cikkben bemutatni az éghajlatváltozás vízre gyakorolt fő hatásainak és az adaptáció szükségességét. Ezt követően, a hatásokra válaszul adható különböző perspektívák bemutatására kerül sor. Ezek a perspektívák magukban foglalnak egy szakaszt az éghajlatváltozás hatásaira adandó válasz szükségességéről, a döntéshozatali eljárásokra helyezendő különös figyelem szükségességéről, valamint a nagyobb pénzügyi ráfordítások szükségességéről. A következő perspektíva azt a dialógust mutatja be és tárgyalja, amely ráirányította a figyelmet a vízhez kapcsolódó klimatikus adaptációra az ENSZ Éghajlatváltozási Keretegyezményének (UNFCCC) tárgyalásai során. Ezeken a különböző perspektívákon keresztül a cikk bemutatja a vízbiztonság és az éghajlatváltozás széles terét.

Kulcsszavak: *klímaváltozás, gazdaság, hatások, perspektívák, vízbiztonság.*

IMPACTS OF CLIMATE ON WATER AND THE NEED FOR ADAPTION IN WATER MANAGEMENT

Since the fourth Assessment Report of the Intergovernmental Report on Climate Change (IPCC, 2007)[2] the climate change models have been refined. Models have been improved by including new feedbacks (e.g. aerosols) and additional components of the earth systems, for example, integrated carbon and nutrient cycles. The main climate change impacts on water security will be caused by changes in precipitation patterns. Future changes in rain and snowfall remain uncertain, although some robust patterns are evolving. An important aspect, often ignored but equally important, is the expected increase in evaporation due to higher temperatures. While precipitation projections are uncertain, changes in temperature are much better projected by General Circulation Models[3]. The overall tendency is for the dry regions to become drier and the wet, wetter. In terms of run-off and river flows, multi-model projections based on climate model runs used in the large scale model intercomparison projects CMIP3 and CMIP5 show consistently (across models) decreased water availability in southern Europe, central Asia, southern Australia and south-western US[4]. For South-East Asia, tropical East Africa and at high northern latitudes there is a consistent pattern of increasing water availability. In some regions the projected future changes are similar to the recent observed changes in rainfall. This is, for example, the case in the Mediterranean and in southern Australia where precipitation rates have reduced over the last 60 years and climate models indicate a further reduction in rainfall (IPCC, 2013)[5]. However, the horn of Africa, for example, observed a recent reduction in rainfall while climate models predict a future increase.

[2] Intergovernmental Panel on Climate Change (IPCC) 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the IPCC, Cambridge: Cambridge University Press.

[3] Terink W., W.W. Immerzeel, P. Droogers (2013), 'Climate change projections of precipitation and reference evapotranspiration for the Middle East and Northern Africa until 2050', International Journal of Climatology, 33 (14), 3055-3070.

[4] Haddeland I., J. Heinke, H. Biemans, S. Eisner, M. Flörke, N. Hanasaki, M. Konzmann, F. Ludwig, Y. Masaki, J. Schewe, T. Stacke, Z.D. Tessler, Y. Wada, D. Wisser (2014), 'Global water resources affected by human interventions and climate change', Proceedings of the National Academy of Sciences, 111, 3251-6.

[5] IPCC, 2013: The Physical Science Basic, Working Group I Contribution to the IPCC Fifth Assessment Report.

Climate change will also affect rainfall variability and extremes (IPCC, 2012)[6]. Both wet and dry extremes will increase. Events with high rainfall will increase and droughts will become more frequent. Also river flows will become more variable in the future. In large parts of Europe, the US and southern Asia both the high flows will increase and the low flows will decrease. So even in areas where average water availability will remain stable or increase, water security can be affected by climate change due to more frequent low-flow events. Climate change will not only affect water availability, it will also change water quality due to changes in water temperatures and dilution capacity caused by changes in river flows[7]. In many delta systems climate change will increase future saltwater intrusion. A combination of sea-level rise and reduction in river flow during the dry/summer season increases the salinity in delta systems in, for example, the Rhine, Ganges-Brahmaputra and Mekong basins. Although it is clear that climate change will have an impact on water security there are still large uncertainties in quantification of future water availability[8]. These uncertainties make it difficult to define traditional coping strategies and there is a need to develop flexible approaches and responses such as adaptive water management. The aim should be to reduce vulnerability and increase the resilience and robustness of future water management and structures.

While climate science and a variety of other scientific and technical disciplines have provided widespread evidence of the sensitivity of the water cycle to climate change, much less consensus exists about the vulnerabilities of water resources management to climate change or how new approaches might compensate for, or take advantage of, shifting conditions. For more than two decades, climate sciences have proven useful in framing the need for adaptation. However, the biophysical sciences have made limited contributions to defining how climate change impact studies can be effectively used for adaptation[9]. Currently, downscaled projections derived from climate models are used for climate adaptation by water managers (General or regional Circulation Models, also known as GCMs or RCMs).

While downscaled projections represent the current standard of practice, their usage shows enormous variation and little standardization. For instance, many water managers select only one or two climate models and one or two scenarios for their chosen models, when in theory any of about two dozen climate models are potentially equivalent, with a diverse array of additional scenarios describing various boundary and starting assumptions for each climate model. Thus, many dozens of downscaled measures in water management fit the possible futures of climate scenarios and model studies. Given the computational limits, expenses and high degree of variation between models and even within models under different scenarios, it is understandable that many water managers choose to simplify these

[6] IPCC, 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change, Cambridge, UK and New York, USA: Cambridge University Press, pp.582.

[7] Van Vliet, M.T.H., W.H.P. Franssen, J.R. Yearsley, F. Ludwig, I. Haddeland, D.P. Lettenmaier, P. Kabat (2013), 'Global river discharge and water temperature under climate change', Global Environmenatl Change, 23, 450-464.

[8] Hagemann S., C. Chen, D.B. Clark, S. Folwell, S.N. Gosling, I. Haddeland, N. Hanasaki, J. Heinke, F. Ludwig, F. Voss (2013), 'Climate change impact on available water resources obtained using multiple global climate and hydrology models', Earth System Dynamics, 4, 129-144.

[9] Stakhiv, E.Z. and R.A. Petrovski (2009), 'Adapting to climate change in water resources and water services', CPWC and WWC.

procedures, even though the theoretical basis for cherry-picking models and scenarios is, in itself, not sound. Moreover, the methods used for downscaling affect the resolution of the climate scenarios and the estimated impacts[10].

Several authors have surveyed the literature to promote particular methodologies in order to support a narrower range of best practices. However, more fundamental questions exist for water managers; for example, do climate models provide the degree of confidence and certainty necessary for assessing vulnerability and designing appropriate adaptation interventions for water resources management? Furthermore, water managers must be able to estimate relative impacts from climate change compared to other existing and future 'pressures' on water resources such as population growth, economic development, land use shifts, urbanization, economic cycling and transformation, technological advances, and so on. The combination of climate and socio-economic drivers makes it more complex to cope with future changes.

A growing number of researchers and practitioners argue that climate models are deeply flawed for many applications in climate adaptation and for water management in particular, at least for some types of decisions[11]. Climate models recognized by the IPCC, for instance, were developed as experimental constructs to help climate scientists understand global climate processes and to guide climate mitigation policy, based on differential assumptions about future greenhouse gas emissions. They were not designed as adaption tools. Indeed, the highly quantitative and apparently precise outputs for precipitation quantities, timing and form; air temperature; and evapotranspiration are often not credible for the demanding accuracy needed currently for water resources decisions by water managers, water planners, infrastructure designers and operators, who are often working on timescales that span decades, and potentially even centuries[12]. This is due to the long-term temporal and high spatial scales of resolution of climate models as well as the high degree of sensitivity of aspects of the water cycle across climate models and even across scenarios applied to a single climate model. There is also evidence that many of these models do not capture critical components of the water cycle, such as shifts in extreme event intensity or frequency or changes in vegetation[13].

The lack of confidence in the precision and accuracy of future eco-hydrological conditions prompts difficult choices: do we continue to assume stationarity in the certain knowledge that our information is wrong, use precise but almost certainly inaccurate projected climate decision-making approaches that allow us to make water resources management decisions that are suitable for uncertain future states?

Alternative approaches that match this final option have been slow to develop. There is a recent rise of so-called 'bottom up' analytical methods to contrast them with climate model

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[10] Ehret U., E. Zehe, V. Wulfmeyer, K. Warrach-Sagi, J. Liebert (2012), 'HESS opinions: „should we apply bias correction to global and regional climate model data?", Hydrology and Earth System Sciences, 16, 3391-3404.

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[12] Matthews J.H. and A.J. Wickel (2009), 'Embracing uncertainty in freshwater climate change adaptation: a natural history approach', Climate and Development, 1 (3), 269-279.

[13] Haasnoot M., J.H. Kwakkel, W.E. Walker, J. ter Maat (2013), 'Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world', Global Environmental Change, 23, 485-498.

constrained 'top-down' downscaling methodologies[14]. In essence, bottom-up approaches attempt to describe vulnerabilities inherent to the system in question (e.g., a basin management plan or infrastructure design), looking for tolerances for risk and operational thresholds defines by users, operators or stakeholders to define a vulnerability domain rather than using climate model outputs as the primary parameters. The resulting boundaries may then be matched to a set of relevant climate variables to test the likelihood of passing these thresholds[15]. This approach does not focus on defining the single optimal solution but focuses on defining a range of robust and/or no-regret options[16].

While bottom-up approaches are still evolving in sophistication and complexity, they appear to have significant promise for empowering water managers (rather than climate scientists), as the key actors for water security, to come up with realistic options for adaptation.

DECISION-MAKING PROCESSES

Many aspects of water management have been identified in recent years as being vulnerable to climate change. This includes particular aspects of the water cycle (precipitation, run-off, snowpack), information and data management systems, governance systems, finance mechanisms, ecosystems, operational accountability, and long-lived infrastructure, livelihoods and institutions (IPCC, 2008)[17]. Much water infrastructure is capable of operating over timescales and under climate variability and even change. Many hydroelectric dams, for instance, are over a century old now, while London's urban water supply system dates back to about 1660, entering its modern era in the 1850s. A massive irrigation system built in 254 BC still serves farmers in Sichuan Province[18]. In contrast, if current assumptions about the rate and scope of continued climate change are correct, designing water infrastructure today that can comprehensively address dynamic eco-hydrological conditions in 100 or 200 years is very challenging and perhaps even prohibitively expensive.

An alternative approach to cope with vulnerability is to analyse the decisions which need to be made by water managers and to consider a transition in water management from traditional stationary approaches to non-stationary methodologies. From this perspective, the water community has until recently assumed that our decisions are 'highly durable' and capable of remaining relevant over long periods.

We may be entering an era when infrastructure designers, investors and evaluators may need to consider building in stages, separated by years, even decades, as climate patterns become more evident. Alternatively, infrastructure may need to become 'disposable' or

[14] Ludwig F., E. van Slobbe, W. Cofino (2014), 'Climate change adaptation and integrated water resource management in the water sector', Journal of Hydrology, 518 (Part B), 235-242.
[15] Brown C. and R. Wilby (2012), 'An alternate approach to assessing climate risks', Eos, Transactions, American Geophysical Union, 93 (41), 401-402.
[16] Van Pelt S. and R. Stewart (2011), 'Climate change risk management in transnational river basins: The Rhine', Water Resources Management, 25, 3837-3861.
[17] IPCC, 2008: Climate Change and Water, B. Bates, Z.W. Kundzewicz, S. Wu, J.P. Palutikof (eds), Technical Paper of the Intergovernmental Panel on Climate Change, Geneva, Switzerland: IPCC Secretariat.
[18] Li K. and Z. Xu (2006), 'Overview of Dujiangyan irrigation scheme of anchient China with current theory', Irrigation and Drainage, 55 (3), 291-298.

capable of easily being dismantled or repurposed after a few decades. In contrast, more durable 'adaptive infrastructure' may require the ability to take advantage of multiple operating regimes as regional and local climates evolve into ever more unfamiliar states, much as a single computer can be capable of running under a number of distinct operating systems (e.g., using Linux, Mac OS and Windows all on the same hardware).

Optimizing Options

According to WHO inscriptions the most appropriate method to ensure the maintenance of security of the drinking water supply system is preparing and maintaining of the Water Safety Plans[19].

Future uncertainties in water availability and extremes impose very difficult planning and design challenges. Many existing design, assessment and operational tools may not prove adequate. The level of challenge reflects both the complex and uncertain impacts of climate change on water resources, and the diverse long-term measures needed to enhance resilience and robustness through measures directed at water supply, water use and water safety.

Some 'soft' measures will involve policy and institutional changes to strengthen water conservation and efficiency. The effects of these are often very difficult to identify and measure, in particular since this involves informed judgements about how multiple types of changes will interact. Other measures will involve capital-intensive 'hard' investments with long lifespans. These pose serious challenges in defining metrics for *ex ante* assessment of net benefits over the longer term.

Given these characteristics, adaptation measures to increase the resilience for water resources need to be able to respond to a range of potential climate change impacts under a variety of socio-economic circumstances. The key to accomplishing this effectively will be the capacity to lessen the potential *socio-economic* consequences of climate change for water resources. Moreover, the benefits related to climate change adaptation of both soft and hard measures will be realized only over a longer time frame. To evaluate and compare different water sector adaptation strategies and measures, therefore, water managers need methods that are broad and flexible enough to provide information about longer-term objectives under a wide variety of future conditions.

Such methodologies should provide decision makers with useful information to select sound alternatives in a timely way, while also taking into account the limits of information. Climate change damage costs and adaptation possibilities are rarely incorporated in economic analyses of water programs and projects.

Application of standard cost-benefit analysis for identifying 'optimal' strategies would focus on the minimization of the expected net present value of adaptation costs and residual climate change damage costs over time. Other information gathered with the data for the cost-benefit analysis could be used to address broader social and environmental aspects that do not fit into the aggregate net present value analysis (in particular, distributional impacts). However, obtaining information needed for even standard net present value analysis is complicated by the long time frames of the projects, raising difficult questions as to how

[19] Berek Tamás – Dávidovits Zsuzsanna: Vízbiztonsági terv szerepe az ivóvízellátás biztonsági rendszerében, 2012. Hadmérnök.

future benefits and costs should be discounted to the present and about uncertainties that are often poorly understood, difficult to quantify and shifting over time.

The operational counterpart to this situation is that a variety of approaches may need to be used to address the effects of longer-term uncertainty on the ground. Economic approaches allow for the efficient identification of adaptation measures that provide the largest net benefits to society as a function of costs, barriers, resource availability, behavior and cultural biases. Furthermore, the broadening of these methods enables an examination of issues around risk management, social inequities and distributional impacts of programs. By integrating these aspects the analysis can provide a range of acceptable measures that are robust to existing uncertainties.

Alternative analyses are being used to the more traditional approaches such as cost-benefit analysis. One approach currently being applied to some projects is real options combined with resilience thinking. Real options is a technique developed years ago in finance that is now being adopted more widely for a different range of issues to understand the implications of different decisions in the long term. Long-term investments open the 'option' of a set of different investments while at the same time it closes others (i.e., a set of certain irreversibility). Such a range of options is represented by option prices that depict the net present value that is generated by a range of alternative investments and actions.

With real options there is a 'valuation' exercise of the consequences of moving from one state to another reflected with an option price estimated as the difference in the net present values of different states. This option price allows decision makers to determine whether investments in the long term are worth undertaking vis-à-vis other alternatives and also provides an understanding of the risk and uncertainty inherent. It also informs decision makers how particular actions and/or investments will have irreversible consequences.

The conclusions of the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy highlighted the major problem of the drinking water supplying, namely "in the Community there are the continuous growth in demand for sufficient quantities of good quality water for all purposes"[20].

THE ROLE OF WATER IN THE GLOBAL CLIMATE NOGTIATIONS

The water community has been engaged in the UNFCCC process and events since the early 2000s. The importance of taking action on adaptation is mentioned already in the Convention Text (UNFCCC, 1992)[21] and there is a reference to water resources as well. However, water in particular, and adaptation initially, was not given appropriate attention in the programs and mechanisms of the Convention. The main message of the water community has been that facilitating the integration and application of water knowledge in the bodies and mechanisms under the UNFCCC is necessary in order to ensure the sustainability of adaptation and mitigation strategies and measures. To this end, the notion has been developed

[20] Berek Tamás – Dávidovits Zsuzsanna: Vízbiztonsági terv az ivóvízellátás minőségirányítási rendszerében, 2012. Hadmérnök.
[21] Declaration of UN Framework Convention on Climate Change (UNFCCC, 1992).

that water is not just a sector but a cross-cutting medium through which climate change impacts upon society, economies, livelihoods and environment.

The engagement for getting increased recognition of water-climate linkages was initially triggered by the third IPCC report (IPCC, 2001) and become instrumental in 2001 by the Dialogue on Water and Climate[22]. A number of organizations from across the global water community started to engage in the processes during COP 10 in Buenos Aires, Argentina in 2004. Since then, organizations carrying a water perspective have engaged in the negotiations under the UNFCCC to promote integrated water and climate change policy at an international level. This has been done through targeted advocacy, working together to develop policy recommendations, statements and interventions, as well as coordinating media events, seminars and workshops.

From 2002 onwords, Water and Climate Focus Days were held during the World Water Weeks in Stockholm. These have contributed significantly to the development of the water and climate agenda, and resulted in the appreciation that water and climate need to be integrated in research, policies and operations and that the water community needs to be present where decisions on climate change are taken.

Therefore, in the spring of 2009 a network was initiated that later became the Water and Climate Coalition, WCC. The objective of the WCC was to engage in the climate negotiations in order to try and identify possible avenues for better integration of water perspectives in the climate agenda. The WCC gathered global environmental non-governmental organizations (NGOs) and partnered with organizations like the African Ministers' Council on Water (AMCOW), the Global Water Partnership (GWP) and the Alliance for Global Water Adaptation (AGWA). There has also been a fruitful collaboration with a number of country representatives. The WCC finalized its work in September 2013, but new forms of collaborations, building on the experiences of the WCC, are developing. The most prominent one is the AGWA policy group, which coordinates the engagement of AGWA members in the UFCCC processes. The AGWA policy group was formed in the autumn of 2013 and as of 2014 is led by the Stockholm International Water Institute (SIWI).

The engagement from 2009 onwords moved from generally addressing the need to integrate water and climate policy to dialoguing on negotiation texts and providing concrete suggestions on how water as a fundamental resource could be addressed in different programs and mechanisms. In 2010 and 2011 the WCC advocated for a particular program on water. However, since many countries, although recognizing the importance of water, were concerned about bringing yet another negotiation onto an already overcrowded agenda, the WCC decided to seek ways to link up with existing programs and ongoing negotiations and to identify ways of feeding in water knowledge and expertise at the right time and on the correct level. One example is the engagement in the Nairobi Work Program (NWP) of the UNFCCC.

In the process of reviewing the NWP and deciding on the future role and modalities of the program, actors from the water community have advocated for water becoming one of the thematic priorities. One of the concrete results of the advocacy was the technical workshop on water, organized under the UNFCCC Subsidiary Body for Scientific and Technology Advice

[22] Kabat P. And H. van Schaik (2003), 'Climate changes the water rules: How water managers can cope with today's climate variability and tomorrow's climate change', The Netherlands: Dialogue on Water and Climate.

(SBSTA), to which NWP is related, in July 2012 (UNFCCC, 2012) and that water was suggested to be one of the prioritized cross-cutting themes in the next phase of the NWP (UNFCCC, 2012).

The constellations will probably vary over time, but independent of the exact structure of the collaboration, coordinated efforts are essential and urgent. The water community can contribute a lot in bringing knowledge, increasing dialogue and providing suggestions on how to bridge the global policy and local implantation gap. But this requires resources, good knowledge about the UNFCCC processes, a genuine will to cooperate, inside as well as outside the water box, and a great deal of patience.

The supply of water is a service of general interest as defined in the Commission communication on services of general interest in Europe. Good water quality will contribute securing the drinking water supply for the population. There is a need to balance the impact of climate change in which water can be polluted for any reasons[23].

CONCLUSIONS

Climate change will result in additional challenges in water management and ensuring future water security. Assessment studies clearly show that climate change will affect water resources availability and increase the frequency and severity of both droughts and floods. There is a need for the water sector to adapt to these changes. Continued research and monitoring to improve understanding and knowledge on the impacts of climate change on the water cycle is essential for water management. However, science will never be able to give exact predictions on future climate and weather conditions and exact data for the long-term change in precipitation and hydrology. The inherent uncertainties about the magnitude of temporal and spatial impacts of climate change upon water require new adjustments in established decision-making procedures for investments and operations.

There is need to address climate change adaptation at different levels. At the global level it is important that climate change negotiators now increasingly recognize that water is an important medium through which climate change impacts upon our societies.

Climate change will alter freshwater resources availability and change future flood risks, also in trans-boundary basins and aquifers. These changes increase the risk for water conflicts in the coming decades. To prevent and/or resolve the expected increase in water-related conflicts that threaten water security it is necessary to (re)negotiate trans-boundary agreements on water allocation and quality. Adaptation in the water sector is often focused on addressing the biophysical change or on reducing water scarcity. However, to facilitate investment in adaptation, the economic cost of climate change impacts and the financial benefits of adaptation should also be addressed.

This article has presented a selection of perspectives on ‘water and climate’. The selected perspectives are all complementary but only a part of the multifaceted impacts and responses that climate change poses to the water community and water security.

[23] Berek Tamás – Rácz László István: Vízbázis, mint nemzeti létfontosságú rendszerelem védelme, 2013. Hadmérnök.

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