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Hydropower and water supply: competing water uses under a future drier climate modeling scenarios for the Tagus River basin, Portugal

Paulo Alexandre Diogo (1), João Pedro Nunes (2), António Carmona Rodrigues (3), Maria João Cruz (4), and Nuno Grosso (5)

(1) IMAR & Department of Sciences and Environmental Engineering, Faculty of Sciences and Technology, Universidade Nova de Lisboa, Caparica, Portugal (pad@fct.unl.pt), (2) CESAM & Dept. Environment and Planning, University of Aveiro, Portugal; jpcn@ua.pt, (3) IMAR & Department of Sciences and Environmental Engineering, Faculty of Sciences and Technology, Universidade Nova de Lisboa, Caparica, Portugal (acr@fct.unl.pt), (4) CCIAM, SIM, Faculty of Sciences, University of Lisbon, Portugal, mjcruz@fc.ul.pt, (5) CCIAM, SIM, Faculty of Sciences, University of Lisbon, Portugal, nunogro@gmail.com

Climate change in the Mediterranean region is expected to affect existing water resources, both in quantity and quality, as decreased mean annual precipitation and more frequent extreme precipitation events are likely to occur. Also, energy needs tend to increase, together with growing awareness that fossil fuels emissions are determinately responsible for global temperature rise, enhancing renewable energy use and reinforcing the importance of hydropower. When considered together, these facts represent a relevant threat to multipurpose reservoir operations.

Great Lisbon main water supply (for c.a. 3 million people), managed by EPAL, is located in Castelo de Bode Reservoir, in the Tagus River affluent designated as Zêzere River. Castelo de Bode is a multipurpose infrastructure as it is also part of the hydropower network system of EDP, the main power company in Portugal. Facing the risk of potential climate change impacts on water resources availability, and as part of a wider project promoted by EPAL (designated as ADAPTACLIMA), climate change impacts on the Zêzere watershed where evaluated based on climate change scenarios for the XXI century. A sequential modeling approach was used and included downscaling climate data methodologies, hydrological modeling, volume reservoir simulations and water quality modeling. The hydrological model SWAT was used to predict the impacts of the A2 and B2 scenarios in 2010-2100, combined with changes in socio-economic drivers such as land use and water demands. Reservoir storage simulations where performed according to hydrological modeling results, water supply needs and dam operational requirements, such as minimum and maximum operational pool levels and turbine capacity. The Ce-Qual-W2 water quality model was used to assess water quality impacts.

According to climate scenarios A2 and B2, rainfall decreases between 10 and 18% are expected by 2100, leading to drier climatic conditions and increased frequency and magnitude of drought periods, probably more acute by the year 2100 and in scenario A2. As a result, a decrease in inflows to the Castelo de Bode reservoir between 20 to 34% is expected, with emphasis in autumn. While for the near-term scenarios this is mostly due to a decrease in median annual inflow; for the long-term scenarios this is accompanied by lower inter-annual variability and a decrease of magnitude of wet year inflows. Associated with increased precipitation erosion potential, watershed sediment transport will probably tend to increase, enhancing phosphorous transport into surface water and thus contributing to potential eutrophication problems. However, modeling results do not indicate compromising water quality degradation.

Decreased reservoir inflows should nevertheless be sufficient to sustain water supply, considering an average annual consumption of 160 $hm^3\ y^{-1}$ and the legal prioritization of water supply over hydropower production, as worst case average annual inflows scenarios are estimated between 1 000 and 1 500 $hm^3\ y^{-1}$. On the other hand, considering that hydropower comprises downstream releases averaging 1 400 $hm^3\ y^{-1}$, restrictions to energy production will probably be required to compensate lower inflow periods and guaranty necessary water supply storage volumes. The presented modeling framework provided an adequate tool for assessing climate change impacts on water resources, demonstrating that climate scenarios are not likely to threaten Lisbon's water supply system but emphasizing the need for adequate reservoir management strategies contemplating the risk of competitive water uses in the Castelo de Bode reservoir.