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Re-operating a system of multiple reservoirs to reconcile intersectoral competition for water: The Kafue River Basin in Zambia

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Many dams have been built and are subsequently operated for one primary purpose, typically hydropower generation, without sufficient attention to the multiple social, economic and environmental interests potentially affected by the altered water levels and the disruption of the downstream flow patterns. All these secondary concerns must be optimized assuming the primary uses forms constraints on the resource management, with the result that intersectoral competition, economic inefficiency, and severe negative impacts on ecosystems and livelihoods are often aggravated rather than alleviated. Persistence of existing, suboptimal practices and resistance against the implementation of a more coherent action stems from multiple economic, normative and cultural reasons (Pahl-Wostl, 2005), but also from the multifaceted technical difficulty of putting integrated, optimization-based approaches into practice.

In the Kafue Flats, part of the Zambezi River Basin, the operation of two dams built in seventies has completely altered the hydrological natural regime of this internationally important wetland (WWF, 2004). Backwater from downstream Kafue Gorges reservoir and releases from upstream Ithezi Thezi dam have created a permanently inundated area within the flats and reduced floods elsewhere, with large impacts on wildlife, vegetation and their dependent livelihoods (Bruke et al. (1994); Mumba and Thompson (2005)). The impact of the current operation on the flats and the anticipatory analysis of some alternate operation rules have been considered by several studies conducted in the area (McCartney and Houghton-Carr (1998); Sinyangwe and Stephenson (2005)). However, because of the intricacy of the hydrological system, and the limited availability of long-term reliable data series, a rigorous, multi-objective exploration of the whole space of Pareto-optimal operating policies has not yet been conducted.

In this work, we developed an operational model of the Kafue River Basin that includes the dynamic description of the wetland area as a virtual natural reservoir, whose level variations are induced by both the release from Ithezi Thezi and the backflow from Kafue Gorges. The model is validated against simulated data generated with KAFRIBA model (WWF, 2004). The natural flow downstream from Ithezi Thezi and the flooded surface area in the wetland are assumed as targets of the daily optimal operation of the system, conjunctively with the maximization of hydropower production and the minimization of irrigation water deficit. A batch-mode Reinforcement Learning algorithm (Castelletti et al. 2010) is repeatedly run for different combinations of the objective weights to design Pareto-optimal operating policies conditioned upon the daily storage in the three reservoirs.

Preliminary results show that the proposed approach significantly enlarges the space for compromise solutions, allowing intersectoral competition for the basin's limited resources to be reconciled, at least by the technical point of view. Of course, the actual implementation of any compromise solution does require a more complex decision making process in which the current social and institutional limitations are analysed and addressed.

BIBLIOGRAPHY

- Burke, J.J., M.J. Jones, and V. Kasimon, 1994. Approaches to integrated water resources development and management of the Kafue Basin, Zambia. In: Kirby, C. and W.R. White (Eds.), Integrated River Basin Development. Wiley, London, UK, pp. 407–424.

- Castelletti, A., S. Galelli, M. Restelli, and R. Soncini-Sessa, 2010. Tree-based batch-mode reinforcement learning for optimal water reservoir operation. Water Resources Research, 46, W09507.

- McCartney, M.P. and H.A. Houghton-Carr, 1998. A modelling approach to assess intersectoral competition for water eesources in the Kafue Flats, Zambia, Water and Environment Journal, 12(2),pp 101-106.

- Mumba, M. and J.R. Thompson, 2005. Hydrological and ecological impacts of dams on the Kafue Flats floodplain system, southern Zambia, Physics and Chemistry of the Earth, 30 (6-7), pp 442-447.

-Pahl-Wostl, C., 2005. Information, public empowerment, and the management of urban watersheds, Environmen-

tal Modelling & Software, 20 (4), pp 457-467.
- Sinyangwe, H. and D. Stephenson 2005. Application of the RAFLS model for integrated water resource management for the Itezhi-Tezhi/Kafue river system, Water SA, 31 (4).
- WWF, 2004. Integrated Water Resources Management Project for the Kafue Flats – Phase 2. Decision Making System for Improved Water Resource Management for the Kafue Flats. Republic of Zambia. Ministry of Energy and Water Development.