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Quantifying eco-sustainable water releases from small hydropower plants by means of the Principle of Marginal Utility

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Water use for hydropower production is increasing in mountain regions, as is an awareness of the importance of generating sustainable water releases for riparian ecosystems. Traditionally, hydropower releases have been regulated by minimum flow release policies, but these can have a number of shortcomings. Perona and Dürrenmatt propose a method of determining releases that is based on the Principle of Equal Marginal Utility (PEMU), which considers the environment as a (non-traditional) water user that is in full competition with other uses. Although simple, this model suggests a way of generating quasi-natural flow releases at diversion nodes while maximizing the aggregate economic benefit of all uses, including environmental.

In this paper we demonstrate the implementation of the method of Perona and Dürrenmatt for several real-cases in Switzerland, evaluating the long term performances of various release policies from both an ecological and economic point of view. The model is implemented by proposing some simple environmental utility functions, followed by an examination of: i) the statistics of the flow releases predicted by the model using the "Range of Variability Approach" originally proposed by Richter et al. (1997); ii) the meaning of environmental benefits, through use of a parametric analysis which evaluates the best allocation strategy; iii) the implicit economic valuation of ecosystem health underlying each simulated alternative. This last point is evaluated assuming that allocating a unit of water to the environment and not to hydropower means assigning a higher economic value to the environment. The long term mean of the ratio between the allocated flows may be used as a suitable engineering parameter, which allows for a comparison of the environmental value of water with other uses over the system lifetime. Results are used to explore the idea that the balance between cumulative financial value, loss of biodiversity and the future costs of ecosystem restoration can be used as a means of improving water resource management.