



## **Integrated infrastructural and financial options to manage weather risk in a multipurpose regulated lake**

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Climate and socio-economic changes are expected to increase environmental financial risk, determining revenues to be affected and costs to be increased by weather events such as floods and droughts. A traditional solution to reduce environmental risk is a structural approach i.e. building or modifying infrastructures such as dams and reservoirs, river and lake dredging. An alternative emerging solution is the adoption of financial tools such as reserve funds or third party insurance to hedge the financial losses. Yet, these two strategies are rarely combined and it is often difficult to compare and evaluate them objectively. In this work, we propose a method to design and evaluate integrated structural and financial solutions to reduce the financial risk caused by drought and floods in a shared basin. The approach is developed on the case study of Lake Maggiore, a regulated lake located on the south side of the Alps. The lake is regulated since the '40s to meet downstream water demand and to allow a reliable outflow which sustains several human activities and environmental services. However, the adopted lake regulation and urban development over the years have contributed to increased flood risk along the lake shore. For this reason, the lake management is a controversial topic opposing upstream and downstream stakeholders affected by flood and drought risk respectively. In the last 30 years, several structural projects involving the excavation of the lake outlet, so as to increase the lake outflow, have been proposed, but an agreement among the stakeholders on one or the other has never been possible. From a financial point of view, reserve funds, where each subject keeps a pool of money to cover financial losses, or third party index-based insurance contracts, where an environmental index triggers a payout to the insured party, are possible strategies. The main core and objective of this work are to assess the introduction of a structural action on the water system, combined with the adoption of financial instruments as a hedge against environmental financial risks. In order to properly evaluate and compare physical and financial management strategies, we adopt the Option Price (OP) method which adds the concept of risk aversion to a traditional cost and benefit analysis. The considered physical action is the excavation of the lake outlet (dredging) which would reduce the shoreline risk of flood increasing the water release from the lake's dam. Several levels of excavations are tested in combination with index-based insurance contracts with different levels of coverage. The objective is to evaluate the potential of this integrated solution in efficiently and cheaply reducing and hedging the environmental financial risks of both stakeholders.