CERIS Civil Engineering Research and Innovation for Sustainability

Towards sustainable operation of small hydropower plants: an integrated analysis of e-flow regimes, flow alteration and energy production

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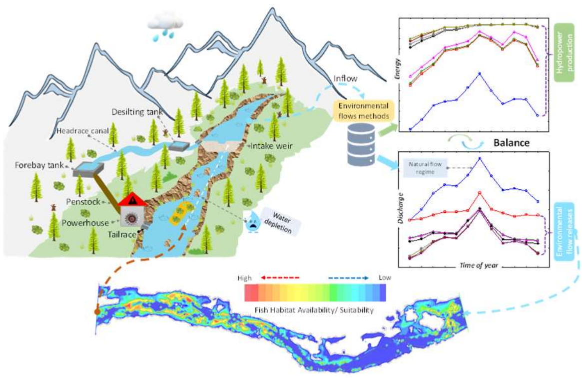
Summary

Small hydropower plants, particularly run-of-river (RoR) types, are widely perceived as sustainable energy providers. Despite the generally positive perception, the social and economic benefits that such renewable energy sources offer they may also substantially alter freshwater ecosystems at different trophic levels. Adequate environmental flows (e-flows) setting is instrumental in mitigating such negative impacts induced by small RoR hydropower plants. However, in general, e-flows design and implantation remain not adequately addressed in small RoR hydropower, resulting in several ecological impacts and some cases, compromising the RoR hydropower profitability. Therefore, to bridge this knowledge gap, this thesis investigates potential solutions to harmonize conflicting objectives, such as maximizing hydropower profitability while ensuring ''good'' ecological status for the freshwater ecosystem. In the second chapter of this thesis, a systematic literature review was conducted to identify the most prominent ecological impacts caused by small RoR hydropower plants and the global awareness against such impacts. The review showed that numerous ecological impacts were directly linked to not rigorous planning and management practices concerning the implementation of the e-flows, periodic monitoring, and lack of effective measures to ensure the riverine ecosystem's longitudinal connectivity. In the third chapter of the thesis, practical indexes were proposed to estimate flow regime alteration due to small diversion RoR hydropower plants' operation. Eight hydrologically-based E-Flows Methods (EFMs) were tested regarding their influence on e-flow regimes and hydropower production. The findings showed that dynamic EFMs preserved several e-flow regime components while ensuring reasonable hydropower production. In the fourth chapter of the thesis, the third chapter's methodology was applied at a regional scale considering 20 small diversion RoR hydropower plants located at four different flow regime types. The findings suggested that pluvial stable river reach guaranteed stable hydropower production and were less sensitive to water diversion for hydropower production. The dynamic EFMs were proven to be the most suitable both in terms of hydropower production and e-flow regimes, regardless of the flow regime type characterizing the river reaches. Finally, the fifth chapter of this thesis presents a hydropower integrated hydrologic–ecohydraulic approach to assess the direct influence of nine hydrologically-based EFMs on barbel (*Luciobarbus bocagei*) fish habitat, hydropower production, and flow regime alteration, among others at a pluvial winter flow regime river reach. Results showed that combined and dynamic EFMs provide reasonable hydropower production while inducing less than 50% habitat loss and flow alteration regarding fish's three life stages for all seasons. Findings resulting in this thesis proved that it is possible to preserve several aspects of the natural flow regime and freshwater ecosystem while ensuring feasible hydropower production through careful design and implementation of the e-flows.

Keywords

Ecological impacts, ecological flow, energy maximization, hydrologic alteration, small hydropower.



Water abstraction for energy generation under various e-flows policies and the implication of these policies on the riverine ecosystem.