



## **Gains from trans-boundary water quality management in linked catchment and coastal socio-ecological systems: a case study for the Minho region**

P.C. Roebeling (1), A.G. Brito (2), J. Rocha (1), H. Alves (1), and J. Mamede (3)

(1) CESAM – Department of Environment & Planning, University of Aveiro, Aveiro, Portugal (peter.roebeling@ua.pt), (2) DEB – Department of Biological Engineering, University of Minho, Braga, Portugal (agbrito@deb.uminho.pt), (3) ARH-Norte – Department of Planning, Information & Communication, Porto, Portugal (joao.mamede@arnorte.pt)

Worldwide, aquatic and coastal ecosystems are affected by point and diffuse source water pollution originating from rural, urban and industrial land uses in catchments, even though these ecosystems are of vital importance from an environmental and economic perspective. Integrated Catchment and Coastal Zone Management (ICCZM) specifically takes into account this inherent relationship between terrestrial land use, surface and ground water pollution, aquatic and coastal ecosystem state, and associated environmental values. To warrant sustainable regional economic development, we need to balance the marginal costs from terrestrial water pollution abatement and the associated marginal benefits from aquatic and coastal resource appreciation. In doing so, however, we need to differentiate between intra- and trans-boundary catchments because benefactors and beneficiaries from water quality improvement are not one and the same. In trans-boundary catchments, private (national) welfare maximizing rates of water quality improvement differ across nations as benefits from water quality improvement generally accrue to one nation while the costs are paid by multiple nations.

While approaches for water quality management in linked catchment and coastal socio-ecological systems are fairly recent though existent, water quality management in trans-boundary catchments poses additional challenges. The objective of this paper is to develop and apply a deterministic optimal control approach that allows us to explore private and social welfare maximizing rates of water pollution abatement in linked catchment and coastal socio-ecological systems. For a case study of the Minho region in the Iberian Peninsula, we estimate nation-specific water pollution abatement cost (based on management practice adoption) and benefit (based on aquatic and coastal environmental values) functions, to determine as well as compare private (national) and social (trans-national) welfare maximizing rates of water pollution abatement.

The presented approach differs from existing approaches in a number of ways. First, we explicitly present an analytical derivation of private (national) and social (trans-national) welfare maximizing rates of water pollution abatement using nation-specific abatement cost functions. Second, the analytical optimal control approach provides an elegant and easily understandable solution concept that contributes to the development of efficient water quality improvement targets. Finally, we go beyond the usual cost-effectiveness analysis based on arbitrary ‘tolerable’ or target levels of pollution as we specifically account for the negative external costs of increased water pollution in the downstream aquatic and coastal environment.

Results for the Minho region show that some private (national) welfare gains can be obtained through the adoption of win-win management practices, leading to a 12% reduction in the annual rate of water pollution and an almost 7% increase in annual regional income. Maximum social (trans-national) welfare gains can, however, be obtained through the adoption of win-win and lose-win management practices across Spain and Portugal, leading to a 36% reduction in water pollution and a 14% increase in regional income. Yet, non-cooperation in water pollution mitigation would only lead to a 16%-32% reduction in water pollution and a 8%-13% increase in regional income. Hence, social (trans-national) welfare losses from non-cooperation between Spain and Portugal would equate to between 16 and 81 million Euros per year.