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ROBUST DECISION SUPPORT SYSTEM FOR THE INTEGRATED TISZA RIVER BASIN NUTRIENTS MANAGEMENT UNDER CLIMATE CHANGE AND EXTREME PRECIPITATION EVENTS

Introduction. The Tisza River Basin, with its total extent of 157,186 km², is the largest sub-basin in the Danube River Basin. In 2011, the five Tisza River Basin countries Hungary, Romania, Serbia, Slovakia and Ukraine entered a new stage in joint transboundary water management to ensure good water quality. The Integrated Tisza River Basin Management Plan (ITRBMP) has been signed focusing on improving Tisza land and water quality and resource management, as well as exploring common approaches towards integrated water resource management in the Tisza River Basin. Particular attention is given to strategies for nutrient reduction, improvement of waste management, integration on land use and water management and reduction of accident risk. In the presentation, we discuss a model for nutrients pollution abatement and trading under uncertainties of anthropogenic and bio-physical processes. Effective and robust controlling of nutrients emissions from agricultural activities is a challenging methodological issue for improving water quality in the river and nearby lakes. The variability of meteorological, hydrological, soil, etc. conditions is an intrinsic characteristics, which cannot be ignored in the analysis of the process or for the design of robust sustainable control measures. The proposed robust DSS is based on an earlier model of robust carbon trading markets [1], however it had to be substantially revised to include specifics of transboundary river water quality analysis. The DSS allows to investigate important tradeoff between maximizing (e.g. agricultural) profits and ensuring adequate water quality (i.e. environmental security) under uncertain weather events and nutrients pollution/emission rates. The emission rates are highly influenced by frequency, length, and intensity of precipitation events. The distribution of emission rates is significantly skewed thus precluding the analysis based on traditional deterministic models, expected utilities, and mean-variance criteria, which may lead to wrong policy implications and induce further risks. The environmental security/water quality constraints are imposed in the form of probabilistic or chance constraints, which are also known as safety or reliability constraints, or Value-at-Risk and Conditional Value-at-Risk constraints. The probabilistic constraints define a nonconvex and possibly highly discontinuous optimization model requiring specific solution methods, implemented in the discussed model. To measure the benefits gained from adopting the robust nutrients management strategies, the Value of Stochastic Solution (VSS) was calculated. The proposed DSS advances methodology in the field of environmental and land resource economics and sustainable development by integrating a dynamical system model with a comprehensive methodology involving two-stage stochastic optimization under probabilistic (security) constraints [1,2,3]. The DSS closely relates to recent developments of the stochastic global land use model GLOBIOM investigating robust food, water, environmental, energy NEXUS under stochastic shocks and systemic risks. The developed nutrients dynamic accounting model is being integrated into the stochastic version of the GLOBIOM, thus allowing to design a tax rate (or permit price) for exceeding environmental constraints with guarantees on reliability. Restricting the risk of exceedingly high nutrients emissions by defining a permit price has high impact for policy design.

Conclusions. The results demonstrate that including uncertainty can significantly change the policy recommendations and bring considerable welfare gains if compared with policies based on traditional deterministic analysis disregarding weather variability. In areas with low water quality, the DSS demonstrates the need for more stringent measures to reduce water pollution. This work demonstrates that the adoption of stochastic optimization methods [3] in environmental economics can provide more robust policy prescriptions under uncertainty and risks, and environmental security constraints.

References

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