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Hydrological, socioeconomic, engineering and water quality modeling aspects for evaluating water security: experience from Greek rural watersheds.

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Water security poses one of the biggest challenges of the century. It is a versatile problem, going beyond the traditional concepts of hydrology and water quality. It is difficult to give a single definition, since water security signifies a "safe operating subspace" within a multi-dimensional space that maps physical resource availability, water quality, demand, infrastructure and economic choices. The main idea of water security, as addressed in the present study, is the need to balance human and environmental water needs.

In arid and semi-arid areas, including Greece, intensification of agriculture accompanied with poor management is a common phenomenon. These attempts to meet economic and productive objectives, combined with the physical characteristics of these areas, has led to quantitative and qualitative water degradation, questioning the sustainability of water resources. In Greece, the Ministry of Environment Management Plans found that only 1 or 2 cases in the country are in "a good status". This study aims to propose a way towards integrated and sustainable management, through hydro-economic tools: water balance, profits from agricultural activities, water value, and water quality. Water security is examined based on these terms in several Greek rural watersheds.

The methodology consists of the estimation of water availability, water demand, and thus water balance in surface and groundwater resources. The profits from the agricultural activities are estimated from a straightforward economic model, based on the gross profits and production costs. Water quality is based on measurements on concentrations of fertilizers, chemical parameters and pesticides, and its improvement is examined through the quantitative replenishment due to several strategies exploiting dilution processes in surface and groundwater. The analysis used data from the period 2005-2015, and a set of management scenarios were examined, suggesting technical measures (e.g. reducing losses, improving irrigation methods) and crop replacement scenarios, taking into account factors affecting these decisions, and also the Ministry's recommendations. The water value was calculated using the "change of the net-income" method. All the above factors' results indicate the degradation of the examined areas.

More specifically, the watersheds of Lake Karla, Almyros, Koronia, and Loudia were selected as the most representative cases. These watersheds seem to have limited water availability, intensified agriculture, poor water quality and management issues. The Lake Karla watershed is characterized from overexploited surface and groundwater resources, Loudia and Koronia watersheds face the same issues plus a strong qualitative degradation, Almyros watershed main issue is the salinization of its coastal aquifer. In conclusion, the first steps that are introduced in this study can be a starting point for more integrated water security management, helping local water managers understand and address the above issues.

Overall, it is a novel attempt to integrate all the above parameters in one framework, for a ten-year horizon, and comparing rural Greek case studies. Non-comparable factors also exist among different case studies, which are discussed, however the evidences support the finding of the general degradation and unsustainable management in the country.

KEYWORDS: Water Security, agricultural watersheds, Greece, Water Resources Management, Hydro-economic modeling, water quality, scenario analysis.