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Designing water efficiency measures in a catchment in Greece using WEAP and SWAT models

Alexander Psomas^{a,*}, Yiannis Panagopoulos^a, Dimitra Konsta^a, Maria Mimikou^a

^aLaboratory of Hydrology and Water Resources Management, Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens (NTUA), 5, Iroon Polytechniou Street, 15780, Zografou, Greece.

Abstract

The Ali Efenti catchment is a rural upstream subcatchment of the Pinios river basin that suffers from seasonal water shortages due to the rapid increase of the total water abstraction in the summer months, which is mainly attributed to local crop irrigation. Catchment modelling is being implemented using two different modelling approaches: a conceptual model based on water balances, the Water Evaluation And Planning system (WEAP), and a physically-based model coupled with routines for irrigation and crop growth, the Soil and Water Assessment Tool (SWAT). Both models were set up, calibrated and validated using observed streamflows. The strengths of the two models were combined in order to design effective, efficient and comprehensive demand-side measures for the urban, tourism, industrial and agricultural sectors to achieve sustainable water management in the Ali Efenti catchment. The comparison of the two models and the results of modelling are being discussed.

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* Corresponding author. Tel.: +30-210-772-2829; fax: +30-210-772-2416.

E-mail address: alexsomas@chi.civil.ntua.gr

1. Introduction

Water scarcity and drought are a serious concern for Mediterranean countries, as well as many central and northern European regions [1]. Since climate change is expected to exacerbate the already existing water stresses, the improvement of water efficiency lies in the core of EU action against water scarcity & drought [2]. Actually, the enhancement of resource efficiency is a key target of the EU 2020 Strategy [3] for smart, sustainable and inclusive growth. The flagship initiative on Resource-efficient Europe [4], which is a part of the Europe 2020 Strategy, supports the transition to a low-carbon, innovative and sustainable economy through the promotion of efficient resource use, including water use. One of the cornerstones of the flagship initiative is the Roadmap to a Resource Efficient Europe [5], which sets out a vision for the structural and technological changes needed up to 2050 and frames future action on the topic. The action towards resource efficiency is further promoted by the recent Communication on Circular Economy [6], which aims at shifting the EU economic and environmental paradigm from a linear to a closed-loop economy. The vision of circular economy focuses on efficiency, reuse, recycling and recovery of resources to minimise total waste production across Europe. The target of increased resource efficiency has been integrated in the policy agenda of the European countries and, depending on the national context, water efficiency has been identified as a priority issue for many of them [7]. There is still a great potential for water saving in all the main water using sectors, such as the agricultural, domestic (i.e. distribution networks, buildings), industrial and energy sectors [8,9]. Water saving measures need to be incorporated in the Programmes of Measures (PoMs) of the River Basin Management Plans (RBMPs), which are developed by the European countries on a regular basis in line with the Water Framework Directive (WFD) [10] with the ultimate goal of achieving good status for surface and groundwater bodies. Designing water efficiency targets and measures to be included in the RBMPs requires deep understanding of the hydrological regime, the sectorial structure of total water use and the relevant socio-economic impacts at local level [2].

The quantitative estimations of water availability, water demand and water consumption both on a temporal and a spatial scale can be supported by modelling tools, capable of simulating the hydrological processes and the water management practices at catchment level for the current status, as well as for various scenario alternatives. Two main types of hydrological models are the conceptual and the physically-based models, which can be (semi-)lumped or (semi-)distributed [11, 12, 13]. The Water Evaluation And Planning System (WEAP) is a conceptual model based on water balances [14], whereas the Soil and Water Assessment Tool (SWAT) is a physically-based model coupled with routines for land use and agricultural management [15]. Both models were used for modelling a small rural catchment in Greece, the Ali Efenti catchment in upper Pinios river basin. The capabilities of the two models were combined in order to address the seasonal water deficit in the region. Effective, efficient and comprehensive demand-side measures were designed for the urban, tourism, industrial and agricultural sectors, focusing on the improvement of water use efficiency.

2. Methodology

2.1. WEAP model description

WEAP is developed by the Stockholm Environment Institute's US Center (SEI-US). Due to major advances, the current version is officially labelled as WEAP21 to distinguish from previous versions. WEAP21 attempts to combine an integrated modelling tool for water resources planning and management with a selection of conceptually simple models for watershed hydrology. It operates on the basic principle of a water balance and can be applied to a single watershed or a complex transboundary river basin system [14]. WEAP21 is considered a conceptual model taking into account the schematization approach for the physical system and the nature of the models used for describing the hydrological processes [16]. The components of the natural system (e.g. catchments, aquifers, rivers and lakes) and the components of the technical system (e.g. reservoirs, boreholes, diversions, pipes, canals, cities, wastewater treatment plants, hydropower facilities and irrigated farms) are schematized using a network of inter-connected model elements without geographical reference. Model elements can fall into two main categories: nodes, where water is demanded or made available for supply, and links, which transfer water between the nodes. The water management model is driven by user-defined demand priorities, supply preferences and environmental requirements for the various

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