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Land cover and future climate effects on the provision of hydrological services: SWAT applied to a medium-sized watershed of northern Portugal

Claudia Carvalho-Santos (1,2,3), João Pedro Nunes (1), António T Monteiro (2), Lars Hein (3), and João Honrado (2)

(1) CESAM & Dept. Environment and Planning, University of Aveiro, Aveiro, Portugal (c.carvalho.santos@ua.pt), (2) CIBIO/InBIO & Dept. of Biology, Faculty of Sciences, University of Porto, Porto, Portugal, (3) Environmental Systems Analysis group, Wageningen University, Wageningen, The Netherlands

Land cover change and future climate conditions may influence the provision of hydrological services. Therefore, it is important to understand how these drivers will affect water supplies and water hazards mitigation, in order to support the planning and management of water resources. In this study, the separated and combined effects of land cover and future climate on the hydrology of the Vez watershed, northern Portugal, were evaluated. The Vez watershed (252 Km2) has a humid climate regime where precipitation is abundant all over the year (1500mm/yr), with exception of a summer with almost no rain. The SWAT (Soil and Water Assessment Tool) model was calibrated against daily discharge, sediments and nitrates, with good agreements between model predictions and field observations related with discharge; the calibration of sediments and nitrates can be considered adequate given the limitations of observed data.

Four hypothetical land cover scenarios were applied under current climate conditions (eucalyptus/pine, oak, agriculture/vine and low vegetation). Results for land cover revealed that the option for one particular scenario would not compromise the overall provision of hydrological services. However, the eucalyptus/pine scenario could reduce the annual water quantity by 7%, and up to 17% in the summer period; and the agriculture/vine scenario could increase soil erosion and nitrate exports.

For the future climate scenario, a statistical downscaling of four ensemble GCMs (General Circulation Models), bias-corrected with ground observations was done for 2021-40 and 2041-60, using the RCP 4.5 medium emissions scenario. An increase in temperature (annual: 1.6ºC; summer: 2.02ºC) and a decrease in precipitation (annual: -3.9%), more pronounced in summer (-25%) are expected in the Vez watershed. Although climate change has only a modest effect in the reduction of the total annual discharge (-7%), the effect on streamflow during summer can be more pronounced (between -15% and -38%). This study shows that climate change can affect the provision of hydrological services by reducing dry season flows, by increasing flood risks during the wet months, and by increasing soil erosion and nitrate concentration in the river.

The combined effects of future climate conditions were also evaluated under eucalyptus/pine and agriculture/vine scenario. Future climate might reduce the low flows, a situation which can be aggravated with eucalyptus/pine scenario. In turn, this scenario can offset the climate-induced increases in the peak flows and soil erosion. Future climate might increase soil erosion and nitrate concentration, which can be aggravated in the agriculture scenario.

These results emphasize the importance of building adaptation strategies that consider both climate and land cover changes, with special attention for the water supply timing during summer, peak flows, and soil erosion during winter. This is especially important when considering the current European Union focus on investing in climate change adaptation strategies.