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Predicting the impact of future land-use and climate change on the groundwater system, Kleine Nete basin, Belgium

E. Salvadore (1), J. Dams (1), O. Batelaan (1,2), and T. Van Daele (3)

(1) Department of Hydrology and Hydraulic Engineering, Vrije Universiteit Brussel, Brussels, Belgium, (2) Dept. Earth and Environmental Sciences, Katholieke Universiteit Leuven, Heverlee, Belgium, (3) Research Institute for Nature and Forest, Brussels, Belgium

Climate changes including global warming and changing air circulation patterns, along with anthropogenic land-cover/use changes are expected to significantly influence both surface and subsurface hydrology in the near future. To be able to plan mitigating or adaptive actions, there is a strong need to study the individual as well as the combined impact of climate and land-use changes on the river, groundwater and wetland system on regional and local scale. Wetlands are particularly sensitive to modifications in water conditions; therefore this study focuses on modeling the impact of climate and land-use changes on the groundwater system and how this will further affect the distribution of most highly valued vegetation types.

The regional study area, the Kleine Nete basin, comprises 580 km2 and is located 65 km north-east of Brussels. Within the basin, the 5.4 km2 sized groundwater dependent nature reserve "Olensbroek" serves as local study area. Initially, the "current" condition of the groundwater system has been determined; meteorological and land-use data for the period 1960-1990 has been used as input in a transient fully distributed physically-based hydrological model, WetSpa, to calculate with a daily time step the two weekly groundwater recharge. These values have been used as input for a transient MODFLOW model of the basin to simulate the groundwater level, flow, drainage and to derive other ecohydrological relevant parameters as mean lowest and highest groundwater level in every location of the basin. Future meteorological conditions have been obtained from a joint collaboration between the Royal Meteorological Institute of Belgium, K.U. Leuven Hydraulics Laboratory and the Royal Meteorological Institute of the Netherlands. All scenarios are based on the hierarchy of Global Climate Model (GCM) output, high resolution nested Regional Climate Model (RCM) simulations, and empirical/statistical downscaling using local observations. Choosing the change in atmospheric circulation pattern and the global temperature change as driving force, a group of four climate scenarios have been generated: moderate temperature change (with and without air circulation) and warm temperature change (with and without air circulation). Considering the combined effect of rainfall and potential reference evapotranspiration three additional scenarios have been simulated: high, mean and low based on the expected hydrological impacts.

Several future land-use change scenarios have been investigated, every scenario consists of a package of policy measures of which the combined effect is calculated. In the aggregation of the policy packages comparable global costs were aspired. The policy measures interact in a direct or indirect way with the three controlling factors for nature and biodiversity: available space, environmental quality and land-use management.

Using the calibrated WetSpa and MODFLOW models, the different land-use and climate predictions have been simulated to evaluate the impact on the groundwater system and to compare future scenarios with the "current" condition.

The results show that wetter winters and drier summers, predicted by several climate scenarios, will produce a moderate increase in monthly average groundwater level and a change in the seasonal variability; more extreme changes have been found when the air circulation was considered in the simulations. Model results also indicated that the groundwater discharge area of the "Olensbroek" wetland will appreciably increase.