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Wetland restoration and its effects on the hydrological conditions and provisioning ecosystem services – a model-based case study at a Hungarian lowland catchment

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The alluvial character of the Great Hungarian Plain has long determined its land use. Human-environmental interactions and landscale patterns were characterised by adaptation to frequent floods and high water availability. Different socio-economical factors in the 18-19th centuries initiated major drainage works and river regulations. These works aimed to adjust hydrological conditions in the floodplains to meet the demands of a new land use approach. This focused on maximizing crop production as the dominant provisioning ecosystem service (ES) instead of the previous land use practice (e.g utilization a broader range of various ES by adaption).

Over time, this new land use-water management strategy led to a trajectory of constrains: 1) Water demands of the agricultural landscape are restricted to a much narrower range than natural hydrological conditions, leading to damages during extremely dry or wet conditions; 2) Artificial drainage attempts to ensure this narrow range during wet periods in the protected former floodplain areas; 3) However, drainage increases water scarcity and drought damage during consecutive dry periods, which cannot be compensated by the irrigation system due to its limited capacity.

As a result of this outdated strategy and contemporary processes, Hungarian landscape management is facing a crisis. Climate and hydrological changes, the aging farmer community, agricultural sector profitability, alterations in the land use subsities, preferring greening and afforestation are among the leading factors of this crisis. These factors are likely to drive current

land use conditions into a significantly altered riverine landscape scenario in the coming decades. Among the current environmental-economic-regulatory conditions, one of the most feasible alternative scenario focuses on water retention and the corresponding adaptive land use. However, the hydrological impacts of such alternative water management-land use on crop yield remain poorly understood.

We examined this by using hydrological simulations at a 272 km^2 study site located next to the River Tisza. Here, the morphology of the heterogeneous terrain offers a remarkable semi-natural storage capacity as it encompasses a deep floodplain area.

We defined six different water governance-land use scenarios. First, three water management scenarios were defined and simulated: reference, excess water retention, and flood retention. Along these scenarios inland excess water (a specific type of flooding) hazard maps were used as an indicator for potentially reclaimable floodplains. Next, an alternative land use map was derived following the prevailing Hungarian landscape planning logic, considering factors such as present location and proportion of current agricultural croplands, grasslands, forests, settlement; soil conditions, water availability (agricultural suitability), and nature conservation status.

An integrated hydrological model was set up with the MIKE SHE software to depict spatio-temporal variations in water resources under present conditions (with an operational drainage system) and for all described alternative cases (without a drainage system). Simulated groundwater levels were a key output used to estimate changes in crop yields at selected pointwise locations. The results indicate significant potential for nature-based hydrological adaptation and co-benefits for provisioning ES.

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