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Shaping long-term human-environmental dynamics in a floodplain landscape of the Pannonian Plain (Central Europe) over the last millennium

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Aiming at a deeper understanding of long-term feedback and interactions, here we reconstructed the changing socio-ecological system of a 9931 km^2 wetland landscape over the last millennium. The study area is situated in the steppe-forest zone representing a major part of World Heritage inland salt grasslands in Europe.

Merging GIS-based historico-geographical and archaeo-topographical records from the 11th–mid-16th centuries, detailed spatiotemporal dynamics of settlement patterns, and random information on vegetation and economic activities were reconstructed. Testing the mean elevation of archaeological remains of settlements (sites) and the average soil agro-suitability in their buffer zones by non-parametric t-tests we found an extensive dispersion of settlements in the fertile deep floodplains at the turn of the 11th and 12th centuries but this reclaimed flood zone had been abandoned by the early 14th century. Statistical test results also suggested that the late medieval (LMA) (14th–mid-16th centuries) group was situated significantly higher than the high medieval (HMA) group (late 10th–13th centuries), and the deserted settlements were situated lower than the permanently settled group. Certain geomorphological formations, floodplain islands, and low fluvial ridges became scenes of settlement abandonment, while a dynamic concentration took place on high ridges. These outcomes suggest that the settlement pattern shrunk and vertically displaced significantly by the 14th-century beginning of the Little Ice Age (LIA) when hydrological challenges emerged all over Europe.

Testing the statistical-based settlement-indicated-flood-zone method in a 237 km^2 area by an integrated hydrological model concerning the elevation of sites, we simulated the HMA, LMA, and late 18th-century extension of flood zones.

However, not only climatic conditions but anthropogenic transformation in runoff conditions of

the upper catchment may also have triggered hydrological challenges in the low-lying plains. The reconstructed transformation of medieval settlement patterns in the Tisza basin (157000 km²) suggests that tens of thousands of square kilometers of virgin forests could have been destroyed in that age. Adapting to a changing hydro-climatic and socio-economic environment a complex community-based 'livestock-water-crop farming' trinity evolved, and livestock breeding and export became the strategic sector in the plain over the next centuries.

The socio-economic basis of mixed farming collapsed by the 18th century. As a response to chronic socio-economic backwardness and emerging hydro-climatic challenges, the aristocratic elite began the biggest river regulation in 19th-century Europe, which transformed the plain into a homogenous agricultural area (1950s cropland covering ~70 %). However, this adaptation strategy failed, and the land use regime of the plain has fallen into a longstanding crisis today. To demonstrate this transformation between the late 18th century (water cover ~30 %) and today (water cover <5 %), we present a series of land cover reconstructions based on digitalized military maps (1782–1785, 1858, 1940–1944 and 1953–1959) and the Corine2018 dataset. Finally, we digitalized the first known flood map (2246 km²) of the region presenting the inundated areas during the catastrophic flood of 1879, the turning point of the century-long wetland reclamation, when the extension of inundated areas was essentially similar to that of the late 18th-century wetlands.