Final report

Regional analyses of the relationship between groundwater and cereal yield variances in Hungary

Groundwater (GW) in many regions is essential for agricultural productivity, especially during drought periods. The shrinking of GW is an important but rarely documented component of the recent global environmental crisis and may threaten food security. The problem cannot be put in proper perspective, because we rarely have datasets long and detailed enough to scrutinise the unfolding effects at regional scales. To address this knowledge gap, we used a 50-y long (1961–2010) and spatially extensive (283 GW wells) dataset from Hungary to examine the GW trends and the sensitivity of the yields of two important crops to GW fluctuations. During 1986–2010, GW levels were significantly (0.21–0.60 m) lower than during 1961–1985 in every region of Hungary and every month of the year. The decrease was 2.24 cm y-1 at the country level. Linear and bootstrap resampling tests indicated weak relationship between GW levels and wheat yields but decreasing GW levels accounted for 18–38% of maize yield variability during the 'warming climate period' of 1986–2010. Calculating the impact of GW on potential food production, a 100 mm higher GW levels would have increased annual maize yields by 0.23 t ha-1 on the Hungarian Plain. However, the registered GW decrease caused an estimated maize yield loss of 0.65 t ha-1, i.e. 11.6 % of the average annual yield during 1986–2010. GW levels fluctuations on the plain showed a significant correlation with August-October soil moisture gridded data over much of the agricultural landscapes of Central and Western Europe, indicating a similar situation in a wider European context. To mitigate the cumulative negative impact of GW decrease and the rising temperature, GW recharge via infiltration of retained water would be an adequate solution. Areas of former floodplains with low agroecological suitability, amounting to almost a quarter of the Hungarian Plain could serve as such water retention areas.

Regional analyses of the relationship between climatic and cereal yield variances in Hungary

This study aims to discover the long-term deterministic relationships between climatic factors, and wheat and maize yields for different landscape types in Hungary over 30-year time windows between 1921 and 2010. Climate change brought successive water deficits, rising mean and maximum temperatures as well as stagnation in precipitation sums. The sensitivity of wheat yield to mean temperature shifted dynamically from the western part of the country (with a cooler climate) to the Hungarian Plain (with a more continental climate) from 1921–1950 to the 'climate change affected' period of 1981–2010. In this 30-y period, rising water deficit reduced maize harvests by an estimated 0.60–0.77 t ha-1 year-1, and climatic factors explained 55–79 % of the variances in maize yields. This research has a contribution to economic history, since the mainstream literature explained both the dynamic growth of the Green Revolution between the 1950s and 1970s, and the unfolding crisis of cropland farming in the post-communist Eastern Europe after the regime changes of the1990s using socio-economic drivers exclusively. Yet, decreasing temperature means and the sums of water deficit would have been beneficial for crop farming in the studied region over the Green Revolution (1951–1980). Then, the collapse of post-communist agriculture in Eastern Europe fell within 1981–2010, when the region became one of the grain producers most vulnerable to climate change. The rapidly growing impact of changing climate on the main cereals urges to rationalise the exaggerated grain production sector, primarily by undertaking a massive ecosystem restoration.

European analyses of the relationship between soil water and cereal yields

The warming of the climate and shrinking freshwater resources pose serious challenges to European agriculture. Meeting these challenges demands a thorough knowledge of the major trends in soil moisture patterns across the continent over time. Charting the available soil water (ASW) content

(m3 m-3) derived from the ERA5 Land dataset in grid cells of 0.1° × 0.1°, the highest values occurred in the Alpine, Baltic and West Balkan countries, as well as in North Western Europe. However, a major part of the Mediterranean and the Carpathian-Balkan regions and Eastern Europe recorded the driest soils over recent decades. The annual average ASW decreased over almost the entire continent from 1981 to 2007, but to the greatest degree in Eastern Europe, while Northern Europe suffered least of all. For the summer half of the year, the available water content of the top 28 cm soil significantly decreased in 45.5% of European croplands, while only 1.0% showed a significant moisture increase. Summer half-year moisture declined across almost the entirety of Eastern Europe, threatening the reproductive stage of wheat and maize vegetation period. Soil water content had a significant positive impact on wheat yields in an estimated 64.3% of European wheat fields, and a negative one in 5.7%. In the case of maize yields the positive impact of ASW was present in an estimated 89.4% of maize-growing areas, explaining an estimated 46 to 72% of maize yield variances in the majority of top European maize-producing countries. In contrast to wheat, negative soil water content impact for maize in the continent was not observed. Significant ASW - wheat and ASW - maize yield relationships were found with decreasing summer half year ASW in 32.0% and 35.2% of European croplands, respectively. The coexistence of the crop yield dependence on soil moisture and the decrease in available soil water content pose a considerable threat to grain production stability over extensive regions of Eastern and Western Europe. These warning signs call for an effective intervention on behalf of soil water conservation in European croplands.

Sea of mud, sea of grain, The Cereal Boom on the Great Hungarian Plain and the Regional Consequences of Waterway Regulation in the Balance (1720–2020)

The paper seeks the historical roots of the backwardness of those areas on the Great Hungarian Plain where, despite their peripheric position and unfavourable agroecological features, monocultural grain production still dominates. Behind the arguments that justified the advance of grain (flood prevention, security of supply, surplus revenue), it explores those underlying but real forces (climate, overpopulation, price trends, land speculation) that, along with to waterway regulation, resulted in the shrinking of animal husbandry and the long-term emergence of an unprofitable economic system. Using historical statistical methods, the authors explore the features of the area in terms of demography, land use, and agricultural yields in the eighteenth century, how these justified the consequent transformations, and the ways in which such features changed due to the regulations. They analyse the advantages of grain production versus cattle breeding, as well as the impact of the monocultural turn, generated by outside forces, on the well-being, inequalities, and demographic relations of the local society and on the ecological carrying capacity of the land, during the cereal boom and in the long run. After all, who paid the bills for the regulation of the Tisza river?