

## Societal resilience to hydroclimatic change in the Roman World

Brian Dermody (1), Rens van Beek (2), Marc Bierkens (2), and Stefan Dekker (1)

(1) Copernicus Institute of Sustainable Development, Utrecht University, the Netherlands (b.dermody@uu.nl), (2) Physical Geography, Utrecht University, the Netherlands

The Romans were masters of water resource management. They employed sophisticated irrigation techniques alongside a highly integrated food redistribution system that provided stable food supplies under the variable hydroclimatic regime within the Roman World. However, a number of paleoclimate studies have demonstrated hydroclimatic changes during the Roman Period that exceeded the amplitude and persistence of normal climate variability. In particular, there was a shift from warmer and more stable hydroclimatic conditions in the Roman Warm Period (c.250 BC – 250 AD) to cooler and more variable conditions in Late Roman Period (after c.250 AD). In this study we use a socio-hydrological model of the Roman world to explore the impact of hydroclimatic changes between the Roman Warm Period and Late Roman Period on the Roman food production and redistribution system.

We calculate crop yields based on temperature and water resource availability using PC Raster Global Water Balance model (PCR-GLOBWB). PCR-GLOBWB is forced with reanalysis climate fields reflecting reconstructions of Roman Warm Period to the Late Roman climate patterns. Cropland areas and settlement patterns are derived from a database of 14,700 Roman settlement sites and crop suitability maps. We simulate food redistribution using a multi-agent food redistribution network with link weights based on Orbis: The Stanford Geospatial Network of the Roman World.

Our analysis indicates a reduction in crop yields during the Late Roman Period compared with the Roman Warm Period owing to cooler temperatures. In addition, our simulations indicate that increased hydroclimatic variability decreased the stability of yields in the Late Roman period. Crop yields in the Western Empire are simulated to have been impacted most by the change in climate owing to cooler average temperatures and greater hydroclimatic variability compared with the Eastern part of the Empire. The food redistribution network was essential to buffer against lower and less stable yields in the Late Roman Period. However, the Late Roman Period coincided with a breakdown in the food redistribution network, making the Western Roman Empire particularly vulnerable to changing climate conditions. Our analysis demonstrates a number of important processes that have general implications for water resource management in food production and redistribution systems.