Extreme weather events and 10,000 years of land-use change in the Gediz River valley

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1. Introduction

The Gediz River valley of western Turkey is one of the most agriculturally productive regions in the county. Water storms deliver most of the valley’s rain, and relatively minor variations in storm tracks can mean the difference between dry years when crops fail and wet years when floods threaten nearly 1,000 sq. km. of the valley. Until the very recent past, the valley’s inhabitants managed these risks with diversified agropastoral and transhumant land-use strategies rather than intensive water-management infrastructure.

Here we reconstruct the frequency of droughts and floods in the valley over the past 16,000 years, and consider the ability of different land-use strategies to minimize the risks associated with extreme weather. We then draw on evidence from settlement patterns, paleo-environmental records, oral histories, early traveler accounts, and municipal records to explore how broad social developments in the valley reflect changing vulnerabilities to extreme weather.

2. Methods

1. Get monthly rainfall data from TraCE-21k general circulation model (GCM) simulation of the past 22,000 years and monthly rainfall from weather station in the city of Salihli for 1940-1999.

2. Downscale and bias-correct GCM data using model output statistics (Michelangeli et al. 2009). Transform the cumulative density function of present-day GCM data to match that of observed data. Use the same transformation on GCM paleoclimate data.

3. For each century, calculate the risk of extreme events:
   - Drought risk = cumulative probability density after rainfall - 0.05
   - Flood risk = cumulative probability density after rainfall + 0.05

4. Use a payoff matrix to find the best land-use strategies given estimated risk (Gould 1983) to assess role of risk in land-use change.


3. Results

- **Chalcolithic to Early Bronze:** High flood risk seems not to have impacted these small-scale communities. More destructive may have been the high drought risk after 6.7ka BP. A century of increased drought risk after 4.1ka BP might have contributed to the dramatic settlement changes between the Early and Middle Bronze Age.

- **Middle to Late Bronze Age:** Successive centuries of moderately increased drought and flood risks, in association with the expansion of economic and social networks, may have accelerated adoption of risk-management strategies. The construction of hilltop citadels around Lake Marmara highlights the degree of centralization and social complexity in this period.

- **Lydian:** The rise of the Lydians and their expansion into a territorial empire occurred during a time of moderate drought risk and a few punctuated periods of high flood risk.

- **Roman, Medieval, and Ottoman:** Periods of settlement expansion, and presumably population growth, punctuated by near-complete settlement hiatuses. The beginnings of these hiatuses correlate well to centuries when drought and flood risks increased either in tandem or in close succession.

We find preliminary evidence that extreme-weather impacts are contingent on particular social vulnerabilities (Jansson and Ankeris 2007). Societies that manage risk by diversifying land use appear to be sensitive to long-term changes in risk, while those that intensify land use are sensitive to extremes lasting only one or two centuries.

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References


