

Characteristics and Environmental Impacts of Compound Drought–Heatwave Events in Taiwan

Sing-Yu Bao¹, *Kuo-chin Hsu¹

1. National Cheng Kung University

Compound drought and heatwave events (CDHEs), defined as the co-occurrence or close succession of droughts and heatwaves, pose growing risks to water, food, energy security and human health. This study investigates the characteristics and environmental impacts of CDHEs in Taiwan, a subtropical island with pronounced hydroclimatic gradients. Daily meteorological data and ENSO indices from 1995–2024 were analyzed for two representative sites located in northern and southern Taiwan. Time series of SPI, HWDI, and ONI were first analyzed using the Bayesian Ensemble Algorithm for Change-Point Detection and Time Series Decomposition (BEAST). Components of SPI and HWDI were related to the possible driving forces of CO₂ and ONI. CDHEs are quantified using the non-linear dependence with a rotated Clayton copula, and lagged relationships are evaluated using Spearman correlations. Results reveal a significant intensification of CDHEs after 2010, driven by greenhouse warming and modulated by ENSO variability. Northern Taiwan exhibits strong lower-tail dependence between drought and heatwaves during El Niño conditions, with pronounced impacts on electricity demand, reservoir storage, agriculture, aquaculture, and heat-related illnesses. In contrast, southern Taiwan experiences more frequent CDHEs during La Niña years, with immediate impacts on agriculture, aquaculture, and public health. The Energy–Food–Water–Health (EFW-H) assessment highlights both immediate and lagged systemic vulnerabilities, underscoring complex interplays among these systems during compound extremes. These findings establish an integrated framework for climate risk assessment and highlight the urgent need to incorporate analyses of compound climate extreme events and cross-disciplinary interdependencies into Taiwan's climate adaptation strategies.

Keywords: compound drought and heatwave events (CDHEs), Copula, Energy–Food–Water–Health (EFW-H) assessment, ENSO, BEAST, lag correlation