Climate-Hazard Screening and the Limits of Calendar Adaptation for Global Endurance Events under CMIP6 Projections

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Abstract

Global marathons and Ironman triathlons concentrate tens of thousands of participants on fixed dates, exposing them to weather and climate extremes, yet no framework systematically quantifies multi-hazard disruption under future climate. We introduce the *Endurance Event Disruption Index* (EEDI), the monthly fraction of days on which afternoon wet-bulb globe temperature (WBGT) exceeds 28 °C or daily precipitation reaches 20 mm d^{-1}. The EEDI measures threshold-exceedance frequency, not organisational cancellation probability. Using five NEX-GDDP-CMIP6 models under SSP2-4.5 and SSP5-8.5, we apply it to 28 major endurance events, including all seven World Marathon Majors, for 1991–2020, 2041–2070, and 2071–2100. Exceedance frequency is assessed over a ±2-day window around each event date, then across all months to identify the optimal scheduling month, $m^* = \arg\min_m \mathrm{EEDI}(m)$. Most events retain low exceedance frequencies at current dates, but Lagos and Singapore already exceed 0.65. By 2071–2100 under SSP5-8.5, strict single-month optimisation would move 21 events and place nine in January. However, the quasi-optimal window, comprising months within 0.02 EEDI of the minimum, has a median width of five months. A tolerant strategy therefore moves only 13 events and limits January to six. Among 20 events with positive adaptation gain, shifts of at most two months recover 81% of the available reduction. Timing-based adaptation is effective but bounded: four tropical venues lose any low-exceedance window by late century. The framework provides a transferable climate-hazard screening tool across diverse global climatic settings for organisers, governing bodies, insurers, and other stakeholders responsible for long-term event safety and continuity planning.