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Attributing hydrological shifts in drought-affected catchments across the Murray-Darling Basin

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Abstract: Severe and prolonged meteorological drought, primarily indicated by rainfall deficits, can directly propagate into reduced catchment runoff. In addition, drought can induce substantial alterations in a catchment's rainfall–runoff relationship, a phenomenon referred to as hydrological non-stationarity. These shifts may amplify runoff deficits during drought and persist well into the post-drought period. For effective drought management and resilience building, it is critical but challenging to disentangle the hydrological impacts of changes in dominant climate and landscape variables that result in non-stationary rainfall–runoff relationships. This study addresses this challenge by attributing hydrological shifts in 123 catchments across the Murray–Darling Basin, which was considerably affected by the Millennium Drought (1997–2009).

A hydrological model was adapted to better capture non-stationary rainfall–runoff relationships by incorporating modules for vegetation dynamics and farm-dam development. The adapted model was then applied to quantify the relative contributions of dominant hydroclimatic and landscape drivers to changes in catchment runoff. The drivers considered include climatic variables (rainfall, potential evapotranspiration and rainfall metrics associated with weather types), vegetation dynamics and farm-dam development. Incorporating these processes improved model performance in terms of higher Nash-Sutcliffe Efficiency and lower water-balance bias, especially for catchments in the southern Murray–Darling Basin and during dry years. Model results indicate that reductions in rainfall and increases in farm-dam storage during the drought period were the primary drivers of reduced runoff during the Millennium Drought and the post-drought periods (Figure 1).

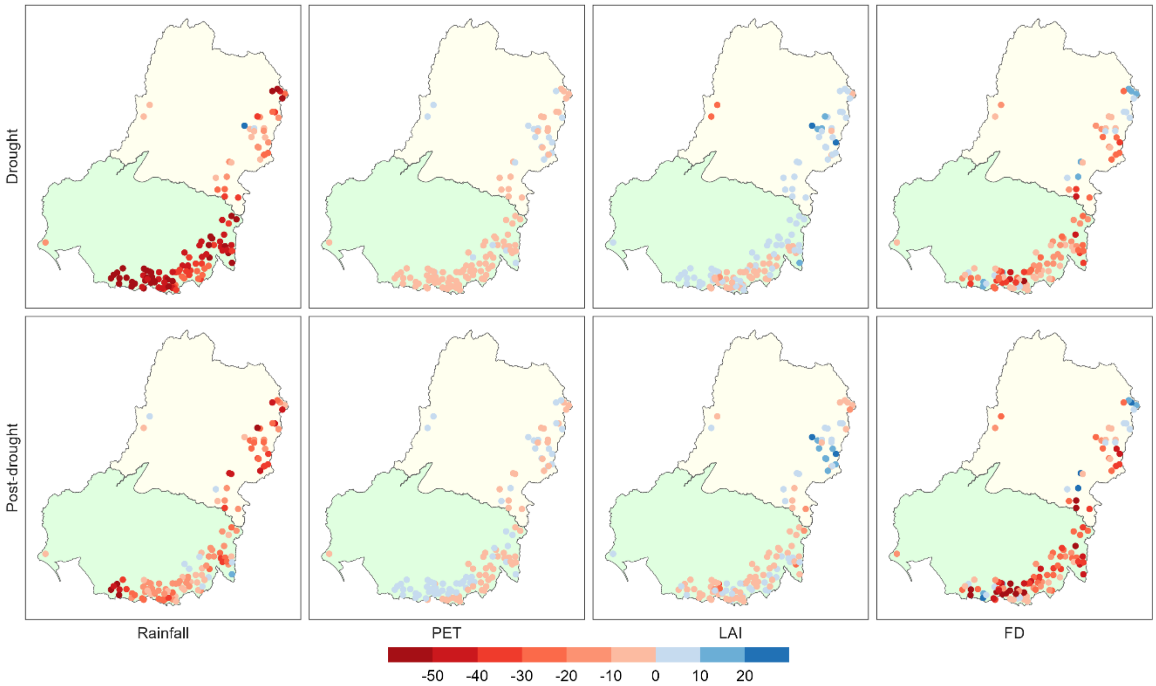

Figure 1 Spatial patterns of contributions (in %) of changes in rainfall, potential evapotranspiration (PET), leaf area index (LAI) and volumes of farm dams (FD) to catchment runoff across the MDB. Northern MDB and southern MDB are with background colour yellow and green respectively.

Keywords: *Hydrological non-stationarity, Drought, Modelling, Murray-Darling Basin*