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When rain returns but rivers don't: Non-stationary response of streamflow to rainfall

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Abstract: The Millenium Drought had a profound impact on catchments across Australia. Rainfall and streamflow reductions relative to pre-drought conditions were widely observed during the drought. In the post-drought period, some catchments have indicated a full recovery of rainfall and streamflow to pre-drought conditions. Other catchments have shown only a partial recovery, or are yet to recover, relative to pre-drought conditions, including catchments that have shown a recovery of rainfall but not streamflow. Most studies attribute changes to climatic factors, while differential hydrological responses among catchments suggest that land cover, landscape characteristics, and groundwater status may also influence streamflow shifts.

South Australia is undertaking an assessment of rainfall-runoff and rainfall-recharge relationships throughout the state (funded by the Australian Government through the National Water Grid Fund), examining how these relationships are affected by changes to climate. The current phase of the study is focused on assessment of potential streamflow shifts across the catchments of the Mount Lofty Ranges and Fleurieu Peninsula. Empirical rainfall-runoff relationships are being developed to reflect the most appropriate period in the historical record to account for 'near future' climate. Analytical methods such as Hidden Markov Models (HMM), Box -Cox transformation and elasticity-based water balance modelling are being used to perform the assessment. These methods involve incorporation of observed rainfall and streamflow along with land cover, actual and potential evapotranspiration, enabling direct assessment of both climatic and anthropogenic impacts—including dam development and land use changes over time (e.g., conversion of dryland agriculture to plantations).

Preliminary results from analysis of Mount Lofty Ranges catchments indicate linkages of streamflow reductions with both climatic and anthropogenic factors such as land cover change. Using remote sensing, evapotranspiration patterns indicate an alignment with streamflow–rainfall shifts detected via HMM. Elasticity analysis suggests a disproportionate reduction of streamflow relative to rainfall reductions in some catchments. Analysis of the impact of land cover changes on streamflow suggests that, in some catchments, these changes may have a stronger influence on streamflow shift than those directly attributable to changes in rainfall.

The results of this study will provide critical rainfall-runoff and associated streamflow data and information to inform water management policies across the South Australian water sector into the future. This includes informing the development of water allocation plans for setting policies and rules of water usage for a range of purposes and for future infrastructure planning and development.

Keywords: *Climate shift, rainfall-runoff relationship, Hidden Markov Models, elasticity-analysis*

