Using data-driven models to identify key drivers of seasonal irrigation water usage

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Abstract: Irrigated agriculture is the largest water consumer globally, accounting for 70% of water use to produce 40% of the world's food. However, irrigation efficiency remains low with a global average of only around 50%. It is expected that irrigation water availability will become more limited due to the impact of climate change and growing competition with other industries while demand for food and fibre will further increase. Therefore, improving irrigation water efficiency is critical for the sustainability of irrigated agriculture.

Irrigation water usage is an informative indicator of irrigation water efficiency, which measures the total volume of irrigation water applied to a cropping area during a season (unit: ML/ha). Irrigation water usage is spatially highly variable in many irrigation districts. Understanding the key drivers of seasonal irrigation water usage can help in developing strategies to mitigate water waste in areas with high water use.

We present a data-driven model to identify key drivers of irrigation water usage between multiple farms, years and crops. The model is hierarchical, allowing samples with different features (crops, years and farms) to be integrated and crop-specific key drivers to be identified. We used multivariate regression to relate irrigation water usage to many explanatory factors. We also added an 'inclusion factor' for each factor to determine whether it is included in the modelling. This enables flexible model structures (i.e., combinations of predictors) to be explored by allowing key factors to be selected based on the uncertainty in model structures. In addition, we included a crop-specific term in the multivariate regression to capture the between-crop difference in irrigation water usage.

The model is tested in a major irrigation district – the Coleambally Irrigation Area (CIA) in southern New South Wales, Australia. The CIA is semi-arid with dry and hot summers and wet and cool winters. Summer is the main irrigation season, and the dominant summer-irrigated crops include corn/maize, cotton and rice. We investigated approximately 300 summer-crop farms from 2011 to 2019. The CIA is a modernised irrigation district equipped with automatic flow gauges on farms, providing real-time irrigation water delivery measurements. The on-farm gauging system provides 1) seasonal irrigation water usage as the model predictand, and 2) detailed delivery records that allow irrigation practice factors (irrigation frequency, intervals, etc.) to be calculated as driving factor candidates. Other driving factors explored in this model include soil, climate, and annual water allocation, which were obtained from public databases. Results showed that irrigation practices and soil types are key factors of variation in seasonal irrigation water usage. This indicates that farmers can potentially adjust their irrigation practices to reduce water waste, which in turn improves water efficiency in the whole irrigation district and makes the irrigated agriculture system more sustainable towards possible future drought.

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