Assessing the resilience of urban water management to climate change

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Abstract

Incidences of urban flood and extreme heat waves (due to the urban heat island effect) are expected to increase in New Zealand under future climate change (IPCC 2022; MfE 2020). Increasingly, the mitigation of such events will depend on the resilience of a range Nature-Based Solutions (NBS) used in Sustainable Urban Drainage Schemes (SUDS), or Water Sensitive Urban Design (WSUD) (Jamei and Tapper 2019; Johnson et al 2021). Understanding the impact of changing precipitation and temperature regimes due climate change is therefore critical to the long-term resilience of such urban infrastructure and design.

Cuthbert et al (2022) have assessed the trade-offs between the water retention and cooling benefits of different urban greening methods (such as WSUD) relative to global location and climate. Using the Budyko water-energy balance framework (Budyko 1974), they demonstrated that the potential for water infiltration and storage (thus flood mitigation) was greater where potential evaporation is high relative to precipitation. Similarly, they found that the potential for mitigation of drought conditions was greater in cooler environments. Subsequently, Jaramillo et al. (2022) have illustrated the locations worldwide that will deviate from their current Budyko curve characteristic under climate change scenarios, as the relationship between actual evapotranspiration (AET) and potential evapotranspiration (PET) changes relative to precipitation.

Using the above approach we assess the impact of future climate change on the urban water-energy balance in three contrasting New Zealand cities (Auckland, Wellington, Christchurch and Invercargill). The variation in Budyko curve characteristics is then used to describe expected changes in water storage and cooling potential in each urban area as a result of climate change. The implications of the results are then considered with respect to existing WSUD guidelines according to both the current and future climate in each location.

It was concluded that calculation of Budyko curve deviation due to climate change could be calculated for any location and land-use type combination in New Zealand and could therefore be used to advance the general understanding of climate change impacts. Moreover, the approach could be used to better define the concept of urban infrastructure resilience and contribute to a better understanding of Budyko curve dynamics under climate change (questions raised by Berghuijs et al 2020)).

Whilst this knowledge will assist in implementation of national climate change adaptation (MfE, 2022; UNEP, 2022) and improve climate resilience in urban areas in New Zealand, the approach could be repeated for any global location for which present and future mean precipitation and temperature conditions are known.