Disaggregation of daily rainfall data into hourly rainfall data using statistical methods for stormwater management in urban areas

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In the recent past, low-lying areas close to riverbanks and urban agglomerations have witnessed frequent floods due to inadequate mapping of flood zones and rapidly growing impervious areas in cities/towns. This inadequacy is due to the use of design storms for run-off estimates, which do not account accurately for antecedent moisture conditions. Furthermore, when using daily rainfall data, capturing accurate run-off estimates becomes challenging as rainfall characteristics such as duration and intensity are not accounted for. These problems can be addressed with long-term hourly rainfall data. However, most gauging stations in India have long-term daily rainfall data and hourly data for the last few years. There are various global methods to overcome this data limitation by disaggregating daily data into hourly data. However, well-established, peer-reviewed research on this process is still in infancy in India. Therefore, a methodology has been developed to disaggregate long-term daily rainfall data into hourly rainfall using statistical and probabilistic principles based on sample hourly data. In this study, the run-off estimates derived from disaggregated data closely match those obtained from actual hourly data with similar characteristics when simulated over the Belagavi city catchment area in Karnataka, India. The methodology developed relies on sample hourly rainfall, making it scalable across various locations. It holds promise for resilient urban stormwater infrastructure planning in the absence of long-term hourly rainfall data.

Keywords: Antecedent moisture conditions, hydrological model, rainfall data, stormwater infrastructure, urban areas.

However, in India, hydrological analysis is usually carried out based on design storms derived from the rainfall atlas of the India Meteorological Department (IMD), iso pluvial maps or 1/3rd rule. The models based on these design storms do not capture pre-event hydrological conditions in the catchment. Therefore, run-off estimates are either underestimated or overestimated depending on the assumptions. Urban India faces flooding risks due to this inadequate stormwater infrastructure planning[1], exacerbated by climate change and urbanization.

To avert these flooding issues, accurate run-off estimates using hourly rainfall data are essential. However, most Indian gauging stations provide long-term daily rainfall data, which is insufficient for continuous H&H modelling, as it fails to capture actual rainfall intensity patterns. Therefore, disaggregating long-term daily data into hourly timesteps is necessary. Many models have been developed to downscale daily rainfall to hourly rainfall. Glasbey *et al.*[2] used the calibrated Bartlett–Lewis model to disaggregate daily rainfall into hourly rainfall. However, the drawback is that disaggregated values are to be scaled to match the measured rainfall values, as the reference storms do not preserve the statistics of the regions. Koutsoyiannis and Onof[3] have also reported on the disaggregation of daily rainfall into hourly rainfall based on the Barlett–Lewis model.

Scott Socolofsky *et al.*[4] carried out stochastic disaggregation of daily rainfall data into hourly rainfall data based on a sample of hourly rainfall data from a nearby rain gauge instead of statistical distribution systems. Andreas Efstratiadis *et al.*[5] have addressed the drawback of the