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Spatio-temporal variation of land use specific contributions towards stormwater runoff using computational hydrograph separation.

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The quantification of land use related storm water contributions in urbanizing catchments is of high importance when addressing flood related causes, risks and mitigation strategies. When it comes to understanding hydrological processes in relation to floods, catchments under urban development have an additional degree of complexity due to the patchwork of paved and pervious areas as well as soil compaction. The estimation of runoff contributions from pervious areas remains highly uncertain and its significance is often neglected in temperate regions. However, in tropical regions their contribution might be significant and its non-linear behaviour increases the complexity when quantifying land cover specific runoff contributions for flood modelling and prediction purposes. This study aims at quantifying the spatio-temporal variation of land cover specific runoff contributions in an urbanizing landscape using computational hydrograph separation. The catchment is 75% covered by bushes, trees, grass patches while the other 25% can be identified as buildings, roads and parking lots. High resolution discharge time series were collected from 2011-2012 at the outlet and 13 sub-catchments, covering various ratios of land covers and soil types. Infiltration measurements were performed for the occurring pervious land uses and soil classes and included a detailed analysis on soil compaction. A finite element numerical model was calibrated and used to estimate infiltration rates under various rainfall intensities for the monitored land uses. Computational hydrograph separation was performed using a numerical distributed hydrological-hydraulic model which was calibrated at sub-catchment level. Model performance was based on overall and event based Nash-Sutcliffe efficiencies (NSE). The simulated runoff response from various land uses was analysed against dry weather period, rainfall intensity and magnitude. The time of concentration of the various sub-catchments lies between 2.2 and 15.1 minutes while for the entire catchment a time of concentration of 17.9 minutes was found. Average NSEs were good at sub-catchment and catchment level (0.6-0.9). However, sub-catchments with an increased natural character (bushes, grass) had lower NSE values (0.3-0.5) for rainfall events <20mm compared to events >20mm (0.6-0.9). Land use specific contribution analysis revealed a clear correlation between paved land surfaces, rainfall magnitude and duration. Overall bushes and flatt grass areas contributed between 2.1 and 60.4 % to the overall runoff at catchment scale while steep grass areas contributed between 6.7 and 16.6%. Paved land uses on the other hand, depending on their classification contributed between 1.4 and 55.9%. The contribution of paved surfaces to stormwater runoff exceeded 50 % when rainfall magnitude and intensity were lower then 20 mm and 14.8 mm h-1, respectively. These results showed that the significance of runoff response of pervious areas increases with increasing rainfall intensity and needs to be considered when designing water sensitive urban infrastructure for flood risk reduction in tropical regions.