Comparison of the effects of Nature-Based Solutions on urban runoff in Kigali using different parametrisations

Many cities in the world, including the capital city of Rwanda, Kigali, face rapid and unsustainable urban developments, increasing the prevalence of paved surfaces. The combined effect of urbanisation and climate change cause the rainwater peak discharges and thus the number of flooding events to increase over time. Therefore, there is a need for applying Nature-Based Solutions (NBSs) which complement the more traditional grey flood reduction measures, because of their ability to adapt to changing environmental conditions. Previously, the hydrological wflow Simple Bucket Model (SBM) has been used to estimate the effects of NBSs on the urban runoff in Kigali. This approach is referred to as the old implementation approach in this study. The effects computed by the old approach are uncertain, because of the lack of quantitative data and challenges to parametrise NBSs. Hence, the aim of this research is to compare the effects of NBSs on urban runoff simulated with the old NBS implementation into wflow-SBM and a more physically based NBS implementation, such that it also benefits NBS studies in other catchments where different hydrological models are used.

Some limitations of the old implementation, that are improved, include the use of unrealistic roughness (Manning) values, the omission of infiltration, and the implementation of surface runoff harvesting (e.g., ponds and retention areas) and small-scale NBSs. Sensitivity analyses of the model parameters and fluxes show that infiltration is a hydrological process that is relevant for the peak runoff and should be included when determining the effects of NBSs. The parametrisation of surface runoff harvesting NBSs is improved by using the function for paddy areas instead of increasing the branch trunk storage. After the implementation of NBSs, the individual and combined effects are obtained in terms of the delay of the peak runoff, and reductions of the maximum runoff and peak runoff volume compared to the original runoff.

As shown in Figure 1, the most important conclusion is that the old implementation is likely to underestimate the effects of NBSs. This is suggested because the new implementation includes infiltration and an improved implementation of surface runoff harvesting NBSs. Also, the parameter value changes are generally larger in the new implementation than in the old implementation. NBSs are especially effective in preventing flood hazards in Mpazi, which is a sub-catchment consisting of steep slopes and paved areas. According to the new implementation, combining all NBSs could lead to a 90% reduction of the maximum runoff in this sub-catchment. In the other two sub-catchments, the maximum runoff reduces by more than 40% for a rainfall return period of two years.

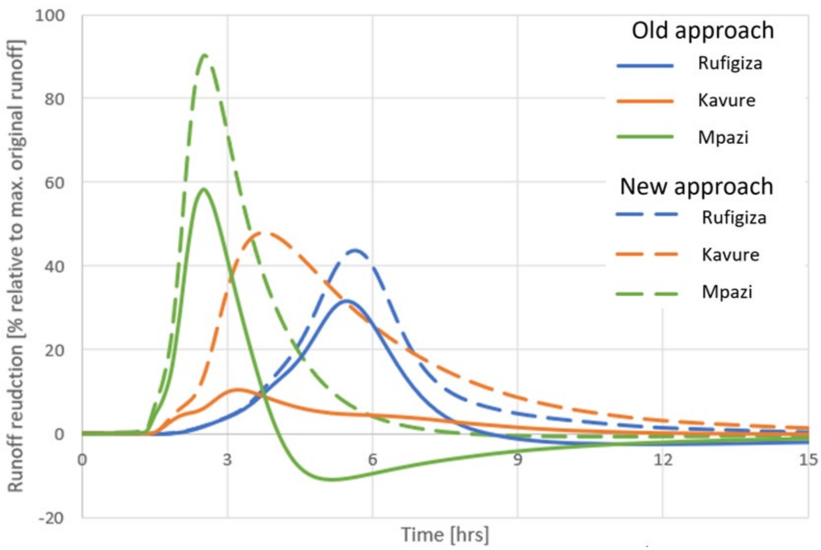

Figure 1: comparison of combined effects of NBSs for the old and new approach for a rainfall return period of two years and different sub-catchments

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