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Estimating Optimal Small Hydropower Portfolios in Data Scarce Southern African Regions

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Small, run of the river hydropower (SHP) has the potential to help provide rural regions in developing countries with access to power. Satellite rainfall products can be used in these often data sparse regions to drive a series of linked models to determine locations feasible SHP sites. However, the inherent uncertainty in satellite rainfall products are a significant source of error, and this must be quantified. Additionally, there is a trade-off between the benefits of power produced from SHP and the cumulative environmental impacts they may produce when multiple are implemented across a basin, and it is important to assess this trade off.

The first part of this study calculates the uncertainty in predictions of SHP potential due to satellite rainfall uncertainty across a data sparse catchment. Comparisons of predicted power and its uncertainty are then made at locations where known SHP sites are located, to evaluate the model's usefulness. The second part of the study involves assessing the trade-off between the cumulative power output and cumulative environmental impact of a range of SHP portfolios, to assess at which locations it is best to construct in order to maximise power output benefits and minimise negative environmental impacts.

A calibrated, linked VIC–LISFLOOD hydrodynamic model driven by different satellite derived rainfall datasets was constructed at 5km resolution on the Pungwe Basin in Mozambique / Zimbabwe. The VIC model was calibrated to a single available GRDC gauging station. A LISFLOOD-FP hydraulic model with sub grid channel representation of small rivers was created from the HYDROSHEDs network, river widths extracted from multiple databases, hydraulic geometry relationships for bed depth, and MERIT DEM. Modelled flow from the 5km VIC cells were routed into each 90m LISFLOOD-FP river pixel. Power Duration Curves were then derived for each river pixel across the basin, and the modelled power predictions were evaluated using six known SHP sites in the upper reaches of the basin. Geostatistical techniques were then applied to generate ensembles of satellite rainfall realisations, which were propagated through the model chain, in order to establish the uncertainty in the modelled power.

Broad assessment of environmental impact has been made based on impacts SHP impacts on river connectivity, with subsequent multi-objective optimisation to analyse the trade-offs between different portfolios based on cumulative power output and impact on river connectivity using the NSGAII algorithm, and thus suggest optimum locations.