EGU21-1924
https://doi.org/10.5194/egusphere-egu21-1924
EGU General Assembly 2021

Exploring stage-based flood frequency analysis for flood inundation mapping

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Floods are one of the worst natural hazards around the globe and around 40% of all losses worldwide due to natural hazard have been caused by floods since 1980s. In India, more than 40 million hectares of area are affected by floods annually which makes it one of the worst affected country in the world. In particular, the Ganga river basin in northern India which hosts nearly half a billion people, is one of the worst floods affected regions in the country. The Ghaghra river is one of the highest discharge-carrying tributaries of the Ganga river, which originates from High Himalaya. Despite severally affected by floods each year, flood frequencies of the Ghaghra river are poorly understood, making it one of the least studied river basins in the Ganga basin. It is important to note that, like several other rivers in India, the Ghaghra also has several hydrological stations where only stage data is available, and therefore traditional flood frequency analysis using discharge data becomes difficult. In this work, we have performed flood frequency analysis using both stage and discharge dataset at three different gauge stations in the Ghaghra river basin to compare the results using statistical methods. The L-moment analysis is applied to assess the probability distribution for the flood frequency analysis. Further, we have used the TanDEM-x 90m digital elevation model (DEM) to map the flood inundation regions. Our results suggest the Weibull is statistically significant distribution for the discharge dataset. However, stage above danger level (SADL) follows General Pareto (GP3) and Generalized Extreme Value (GEV) distributions. The quantile-quantile plot analysis suggests that the SADL probability distributions (GP3 and GEV) are closely following the theoretical probability distributions. However, the discharge distribution (Weibull) is showing a relatively weak corelation with the theoretical probability distribution. We further used the probability distribution to assess the SADL frequencies at 5-, 10-, 20-, 50- and 100-year return periods. The magnitudes of SADL at different return periods were then used to map the water inundation areas around different gauging stations. These inundation maps were cross-validated with the globally available flooding extent maps provided by Dartmouth flood observatory. Overall, this work exhibits a simple and novel technique to generate inundation maps around the gauging locations without using any sophisticated hydraulics models.