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A comparison of multi-criteria and machine learning weighting for flood risk assessment in the Southern Ontario, Canada

Rahma Khalid and Usman T Khan
York University, Canada (rshakir@my.yorku.ca)

Floods, the most frequent and severe of natural disasters worldwide, inflict significant social, environmental and fiscal impacts, including: loss of human life, damage to natural habitats and damage to infrastructure. Flood risk mapping can be used to mitigate these impacts as it provides a holistic approach to identifying flood prone areas by simultaneously considering socioeconomic and environmental indicators. This research compares the performance of two multi-criteria decision making methods, and one Machine Learning (ML) method in the development of flood risk mapping. This approach was first developed and validated for the Don River watershed in the Greater Toronto Area and subsequently extended to several other watersheds across Southern Ontario. Remote sensing data such as Digital Elevation Models and landuse and lancover datasets were used to develop the environmental flood hazard extent, and combined together with socioeconomic indicators, flood risk maps were developed using subjective and objective weighting schemes in a GIS analysis. The subjective maps were produced using the Analytical Hierarchy Process (AHP), the objective maps were produced using the Shannon Entropy method and the ML maps were produced using Artificial Neural Networks. The accuracy of these maps was compared against the floodplain map of the Don River. For a range of flood risk severity, where 1 was very low risk and 5 was very high risk, the AHP maps were superior in identifying areas where flood risk severity was 4 or greater. Conversely, the Entropy maps were superior in identifying areas where flood hazard risk was 5, however the difference in accuracy for both scenarios was marginal between the two methods. The accuracy of the ML maps showed marginal superior performance under both scenarios in comparison to the multi-criteria maps. Additionally, the uncertainty in the combination of flood risk indicators was quantified through a sensitivity analysis focusing on the discretization of the number of classes in each indicator dataset. The outcome of this research provides an accurate and simplified alternative to using hydrological and hydraulic models, especially when insufficient data limits the use of hydrological and hydraulic models. Future research should focus on an optimisation approach to the discretization of classes in indicator datasets.