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Machine Learning Model to Reproduce Nature-Based Solutions for Flood and Drought Mitigation

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Reducing the threat of severe spatiotemporal events like floods and droughts is raising concerns for water resource development and management. The severity of drought and floods increases more due to human interventions. Recent studies have focused on finding long-term solutions that mimic nature's process, while posing no environmental risks and targeting sustainability in traditional approaches. The terminology given in Europe for this natural solution is Nature-Based Solutions (NBS). Some examples of NBS are afforestation or reforestation, storage areas, vegetation buffers, and riparian forest. The main principle of NBS is that they slow down the rate of runoff by boosting interception, infiltration, or storage for flood water, hence mitigating the risk downstream. However, there is still not enough experimental nor theoretical experience on how they could be implemented to optimize their use. The way to represent NBS and the scale of implementation in models and real life is for now a process based on approximated propositions of the empirical knowledge of experts in the field. Although some experience have shown important contributions, this is not enough for an optimal implementation and a complete understanding of all possible outcomes. This is the problem expected to be addressed in this research. The main goal is to construct machine learning models to explore their use as an alternative (surrogate) that will aid in performing multiple scenario analyses of NBS, and quantifying their impacts. This approach will consider spatial and temporal data and create a link between several environmental variables and human actions without explicitly knowing the physical behavior of the system, yet clustering(grouping) behaviors or processes responses to structural properties of the hydrological model representation. The case study area for this research is the Bagmati River Basin of Nepal, covering a catchment area of 2822 sq. km, and the flow is dominated by spring and monsoon rainfall. Soil and Water Assessment Tool (SWAT) is used and the baseline scenario (without the implementation of NBS) is modeled. Different scenarios of afforestation, ponds, and conservation tillage will be intervened in the SWAT model and the changes made by those interventions will be replicated in Artificial Neural Network-Multi Layer Perceptron (ANN-MLP). Several unforeseen scenarios will also be tested in machine learning. Thus, the Spatio-temporal analysis will be done regarding the impact of NBS on the flows, and the machine learning model's ability to replicate such complex systems will be evaluated.

The outcome presented here shows the construction of a SWAT model and the preliminary results

of machine learning models capable of promptly predicting changes in flow induced by the adoption of various Nature-Based Solutions. It is anticipated to be a simple, effective, and time-saving way for studying the effectiveness of various Nature-Based Solutions for flood and drought mitigation. Thus, this study contributes to the experiences in interpreting and linking complex hydrological problems in machine learning systems.

Keywords: SWAT, Machine learning, Nature-Based Solutions, Hydrological extremes, Spatio-temporal analysis