Analyzing effects of environmental and climatic variables on snow- melt variability in Northern Pakistan using Deep Learning and Building Typology Data in The Himalayas of Northern Pakistan

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The rapid and unpredictable changes in snowmelt patterns in Northern Pakistan pose significant challenges for water resource management. This study employs deep learning models, specifically Feedforward Neural Networks (FNN), Convolutional Neural Networks (CNN), and Long Short-Term Memory Networks (LSTM), to analyze the temporal variations of snowmelt within the study region. The study utilized a dataset of 37 different climatic and environmental parameters from the Global Land Data Assimilation System (GLDAS), including temperature, precipitation, and humidity from 1948 to 2014, to train and validate the models for accurate snowmelt prediction. The performance of the deep learning models revealed significant insights. The FNN model demonstrated exceptional precision with an MSE of 3.51×10^{-5} and an R- squared value of 0.971. The CNN model, which processes spatial data more effectively, also showed high accuracy, with an MSE of 3.70×10^{-5} and an R- squared value of 0.971. Particularly notable was the LSTM model, optimized for sequential data, which recorded an MSE of approximately 5.28×10^{-5} and an R- squared value of 0.947. Storm surface runoff emerged as the most influential feature with an importance score of 0.8264 highlighting its significant contributions to Snow Melt predictions. These findings underscore the value of integrating deep learning techniques with climate datasets for hydrological predictions. By enhancing the accuracy of snow melt predictions, this research contributes to sustainable water management and supports climate action goals, aligning with SDG 6 (Clean Water and Sanitation) and SDG 13 (Climate Action). The methodologies and results provide a robust framework for ongoing research studies related to climate impact assessment and adaptive resource management.