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Prediction of suspended sediment yield using hydro-climatic variables by Artificial Neural Networks for the Brandu river sub-basin of Upper Indus Basin (UIB)

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Sediment transport in the rivers traditionally can be divided in bed load and suspended load transport. Due to the turbulence of the river flow fine sand, silt and clay particles are transported as suspended sediments. Sediment is transported by the river and basin runoff, wind erosion, river and bank erosions. Estimation of suspended sediments is important for the river water quality, nutrients, river ecology, assessment of land use changes, river hydraulic structures, water courses, storages of dams and hydro powers and their operations.

Measurements of suspended sediments are difficult, cost intensive and require a lot of time. The suspended sediment yield is highly nonlinear. It depends upon a lot of factors for its estimation (e.g. hydraulics, discharge, sediment composition, climate and land use changes etc.) and therefore represents a complex topic in sediment transport. The aim of this study was to use artificial neural networks (ANN) for predictions of suspended sediments and compare it with traditional rating curve and multiple linear regressions using hydro climatic datasets. In this study, soft computing algorithms of artificial neural networks (ANN) were used for Brandu river near Daggar in Upper Indus Basin (UIB). Four ANN Algorithms: 1) Levenberg-Marquardt 2) Scaled conjugate gradient 3) Gradient descent 4) Bayesian regularization of multilayer perceptron (MLP) artificial neural network (ANN) with feed forward back propagation method were used.

Discreet daily data (total 1980 datasets) for the period 1981-2010 of flows, suspended sediments along with basin averaged climatic (temperature, rainfall) parameters were used to train (1-1647) and test (1648-1980) the neural networks for predictions of suspended sediments yields near Daggar in Brandu sub basin. The results showed that flow, rainfall and temperature were significant factors for predictions of suspended sediments. In this study, the Levenberg-Marquardt feed forward back-propagation (FFBP-LM) has proved as the best algorithm for sediment estimations. The estimation of suspended sediments using rating curves was below expectations both for training as well as testing period. Multiple linear regressions model unrealistically predicted some negative values.

The Models performance was evaluated using indices of correlation coefficients (R2), root mean square error (RMSE) and Nash Sutcliffe efficiency (NSE). The ANN using Levenberg-Marquardt backpropagation with RMSE = 5573 tons/day, NSE = 0.749 and R2 = 0.765 in test period is superior to rating curves and multiple linear regressions with RMSE = 75012 tons/day, NSE 0.5453, R2 = 0.558 and RMSE = 8566 tons/day, NSE=0.407, R2 =0.577 respectively. It is concluded that ANN using the Levenberg-Marquardt backpropagation algorithm with hydro climatic inputs is reasonable good for prediction of suspended sediments in Brandu river.