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Determination of riverbank erosion probability using Locally Weighted Logistic Regression

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Riverbank erosion is a natural geomorphologic process that affects the fluvial environment. The most important issue concerning riverbank erosion is the identification of the vulnerable locations. An alternative to the usual hydrodynamic models to predict vulnerable locations is to quantify the probability of erosion occurrence. This can be achieved by identifying the underlying relations between riverbank erosion and the geomorphological or hydrological variables that prevent or stimulate erosion. Thus, riverbank erosion can be determined by a regression model using independent variables that are considered to affect the erosion process. The impact of such variables may vary spatially, therefore, a non-stationary regression model is preferred instead of a stationary equivalent. Locally Weighted Regression (LWR) is proposed as a suitable choice. This method can be extended to predict the binary presence or absence of erosion based on a series of independent local variables by using the logistic regression model. It is referred to as Locally Weighted Logistic Regression (LWLR).

Logistic regression is a type of regression analysis used for predicting the outcome of a categorical dependent variable (e.g. binary response) based on one or more predictor variables. The method can be combined with LWR to assign weights to local independent variables of the dependent one. LWR allows model parameters to vary over space in order to reflect spatial heterogeneity. The probabilities of the possible outcomes are modelled as a function of the independent variables using a logistic function. Logistic regression measures the relationship between a categorical dependent variable and, usually, one or several continuous independent variables by converting the dependent variable to probability scores. Then, a logistic regression is formed, which predicts success or failure of a given binary variable (e.g. erosion presence or absence) for any value of the independent variables. The erosion occurrence probability can be calculated in conjunction with the model deviance regarding the independent variables tested. The most straightforward measure for goodness of fit is the G statistic. It is a simple and effective way to study and evaluate the Logistic Regression model efficiency and the reliability of each independent variable.

The developed statistical model is applied to the Koiliaris River Basin on the island of Crete, Greece. Two datasets of river bank slope, river cross-section width and indications of erosion were available for the analysis (12 and 8 locations). Two different types of spatial dependence functions, exponential and tricubic, were examined to determine the local spatial dependence of the independent variables at the measurement locations. The results show a significant improvement when the tricubic function is applied as the erosion probability is accurately predicted at all eight validation locations. Results for the model deviance show that cross-section width is more important than bank slope in the estimation of erosion probability along the Koiliaris riverbanks. The proposed statistical model is a useful tool that quantifies the erosion probability along the riverbanks and can be used to assist managing erosion and flooding events.

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