



Data-Driven Sensitivity Analysis of River Hydromorphology Indicators Using Machine Learning

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Metrics on hydromorphology are essential for evaluating river conditions under the Water Framework Directive (WFD) and provide a valuable tool for informing effective river restoration. Application of these tools, however, should include consideration of the sensitivity of the constituent indicators and as important step in assessing data quality and model robustness.

In this study systematic sensitivity analysis, using a machine learning-based framework, was performed on the new Morphological Quality Index (MQI) tool for Ireland (MQI v.2.0), obtained from the Irish Environmental Protection Agency (EPA). Analyses was conducted on a dataset from the River Suir catchment, which represents the full range of river types and pressures on hydromorphology in Ireland.

A Random Forest model was developed to model MQI using 16,838 combinations of the 14 key indicators. The model demonstrated exceptional predictive accuracy ($R^2 > 0.98$), highlighting the intricate relationships among indicators. Sensitivity was thereafter assessed by introducing adaptive noise (0.01σ to 3.5σ) to individual indicators, quantifying their influence on MQI predictions.

The results identified A13 (Historic Modifications), F3 (River-Corridor Connectivity), and A8 (Artificial River Course Changes) as the most sensitive indicators, demonstrating significant impacts on model performance metrics such as R^2 and RMSE. Riparian vegetation metrics, including F12 and F13, also emerged as sensitive indicators. The analysis revealed that the MQI tool is highly susceptible and sensitive to changes in these key indicators, suggesting that improving the quality of these indicators might enhance the overall reliability of MQI assessments. These insights into the relative importance of individual indicators in shaping hydromorphological assessments and potential implications for catchment management and restoration initiatives are discussed.

Keywords:

Hydromorphology, Morphological Quality Index (MQI), Indicators, Sensitivity Analysis, Random Forest

