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Giving gully detection a HAND

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Gully erosion affects land and water resources, resulting in serious environmental and socio-economic consequences. To aid mitigation and rehabilitation efforts, gully susceptibility mapping of broader gully-prone regions should be augmented by the rapid detection of existing gully features. Numerous works have been published on (semi-)automated approaches to detect gully erosion, most recently incorporating machine learning. However, upscaling and transferability capabilities of these approaches are rarely investigated. Establishing algorithms that are scalable and transferrable will constrain uncertainties when conducting quantitative analysis, allowing comparable results at different landscape scales and/or geo-environmental settings. Here, we aim to develop and apply a semi-automated approach based on Object-Based Image Analysis (OBIA) with low data needs, at different scales and geo-environmental regions. The segmentation process is underpinned by two gully morphological properties: 1) Height Above Nearest Drainage (HAND) and normalised slope, calculated from a Digital Elevation Model (DEM) with a spatial resolution of 2 m, with 93% coverage of South Africa's 1.22 million km² expanse. HAND is a terrain model that normalises topography according to local relative heights above a drainage channel (herein, a gully channel). While this has been implemented in flood mapping studies for river systems, it remains unused in gully detection algorithms. Slope, which is often used as a gully predictor variable, is used to confine HAND and implemented here as a normalised slope input, calculated by subtracting a convolved mean slope value with a designated filter size from the DEM-derived slope. Detected gully features are refined using expert knowledge, merging, and pixel-based growing and shrinking. Preliminary development at a local gully scale suggests good performance, with an overall accuracy of 82.3% (includes a user accuracy of 65.5% of gully and 99.0% for non-gullied areas, and a producer accuracy of 98.5% for gully and 74.2% for non-gullied areas) and a kappa index of 0.65. We also discuss the broader performance of our approach when upscaling and implemented in other geo-environmental settings covered by the 2 m-DEM.