A Survey of Automated Detection Methods for Illegal Sand Mining along the Pungwe River, Mozambique: An Analysis of Satellite and UAV Data from 2020

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Abstract

Illegal sand mining along riverine ecosystems such as the Pungwe River in Mozambique presents substantial environmental and socio-economic threats. Manual monitoring is often impractical due to the scale and remoteness of these activities. While remote sensing and computer vision offer potential for automated detection, a synthesised review of relevant methodologies is absent. This survey systematically reviews and analyses automated detection methods for illegal sand mining, concentrating on techniques applied to satellite and unmanned aerial vehicle (UAV) data from the Pungwe River region. It evaluates the efficacy, limitations, and technological maturity of different approaches. A structured literature review was undertaken, focusing on peer-reviewed articles, conference proceedings, and technical reports. Detection methodologies were categorised, including pixel-based and object-based image analysis, machine learning classifiers, and deep learning models. Evaluation criteria encompassed data sources, algorithmic approaches, validation methods, and reported performance metrics. Deep learning models, particularly convolutional neural networks, are increasingly dominant, demonstrating superior performance in identifying mining-related land disturbances from high-resolution imagery. A critical reliance on very high-resolution satellite or UAV data for reliable detection was a consistent theme. A significant gap exists in the operational integration of near-real-time monitoring systems.

Automated detection methods show considerable promise for monitoring illegal sand mining but remain largely within a research and development phase. Successful deployment requires addressing challenges related to data accessibility, algorithmic adaptability to local conditions, and the establishment of robust validation frameworks. Future work should prioritise developing open-source benchmark datasets specific to the region, creating hybrid models that fuse multi-temporal satellite and UAV data, and fostering collaborative frameworks between researchers, local authorities, and communities for ground-truthing and system implementation. automated detection, illegal sand mining, remote sensing, satellite imagery, unmanned aerial vehicles, computer vision, deep learning, Mozambique, Pungwe River. This survey provides a consolidated analysis of automated detection methodologies for illegal sand mining, offering a critical reference for researchers and practitioners in the field of remote sensing and environmental monitoring, with specific relevance to the Pungwe River context.