OPTIMIZING PLANETSCOPE-BASED SATELLITE-DERIVED BATHYMETRY: A SINGLE-BAND APPROACH WITH 3D SPATIAL AND STATISTICAL FILTERING

Keywords: Satellite-Derived Bathymetry (SDB), PlanetScope, Statistical Filtering, 3D Geospatial Filtering, Bathymetry Accuracy

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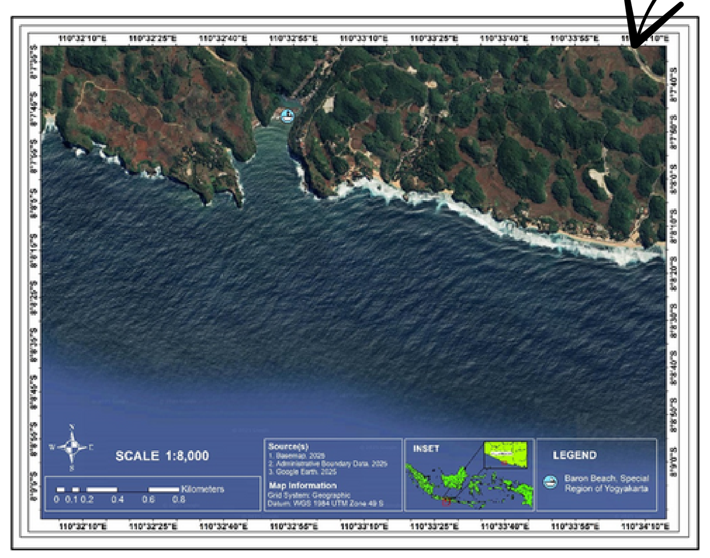
Introduction

Bathymetric information is crucial for navigation safety, habitat mapping, and coastal management (Calder & Mayer, 2003; IHO, 2022). Traditional hydrographic surveys such as SBES and MBES provide high accuracy but are costly, time-consuming, and limited in spatial coverage. Satellite-Derived Bathymetry (SDB) offers a cheaper and more efficient alternative. However, the single-band approach often shows low accuracy (Stumpf et al., 2003; Thomas et al., 2021), which makes optimization necessary.



Study Area

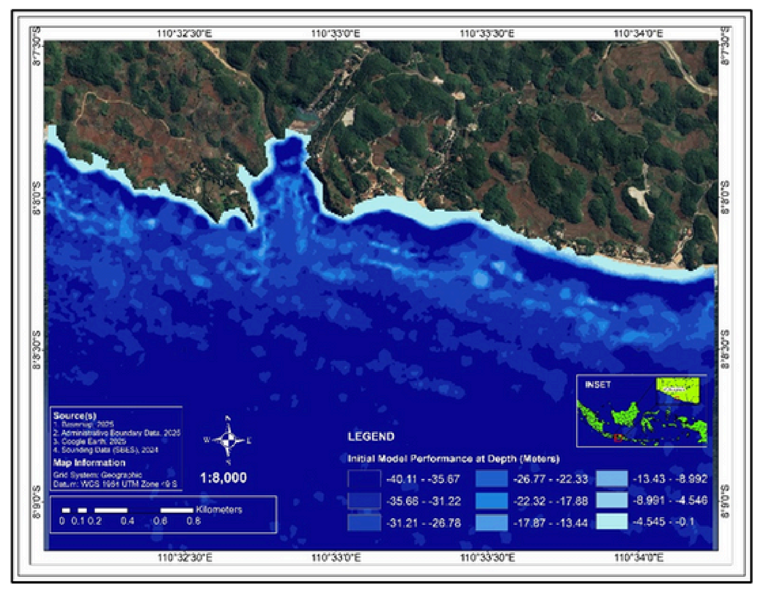
The study was conducted in the coastal waters of Baron Beach, Gunungkidul, Yogyakarta (110°32′–110°33′ E; 8°9′–8°10′ S). Baron is an active tourism and fisheries zone, which increases the demand for accurate and up-to-date bathymetric data.

Objective

This study aims to:

- Optimize PlanetScope-based single-band SDB using Cloth Simulation Filter (CSF).
- Compare different interpolation methods (IDW, Kriging, Natural Neighbour, Spline).
- Validate the accuracy using SBES reference data reduced to MSL.
- Assess the model against the IHO (2022) Order 1 standard.

Map Initial Model



Methodology

01 Pre-processing: radiometric correction → TOA reflectance → NDWI masking → tidal correction

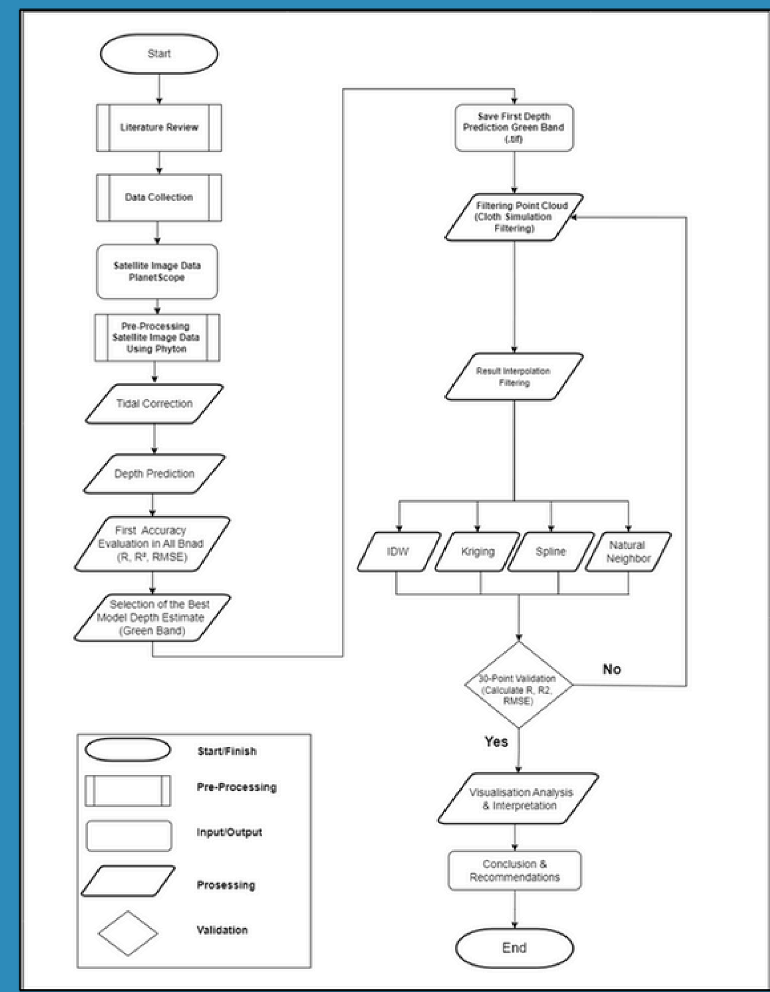
02 Regression: single-band test on red, green, and blue → green chosen (R^2 = 0.211; RMSE = 2.080 m)

03 Filtering: CSF applied to reduce noise in depth point cloud.

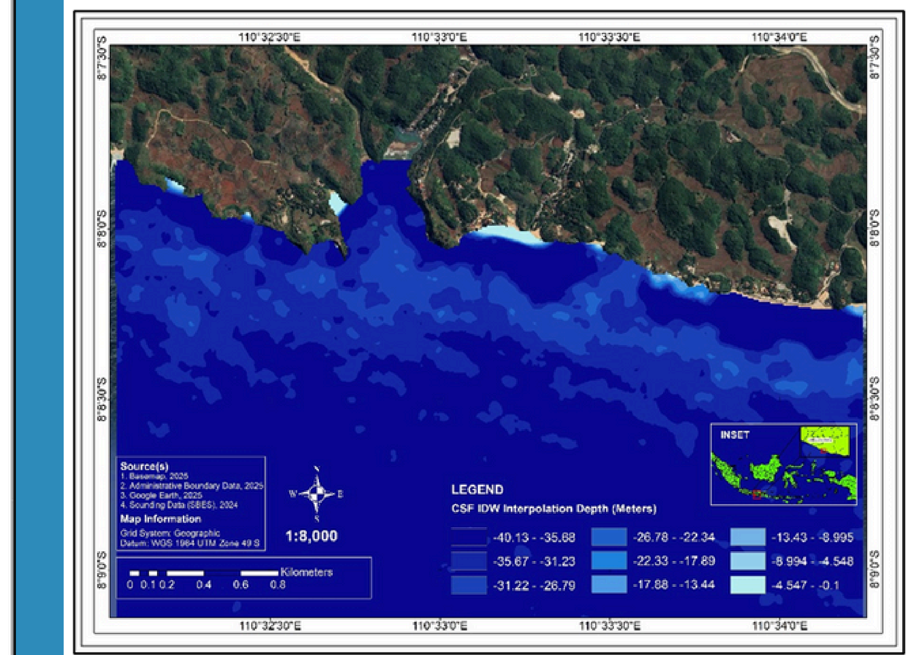
04 Interpolation: IDW, Kriging, Natural Neighbour, and Spline.

05 Validation: 30 independent SBES points using R, R^2, RMSE.

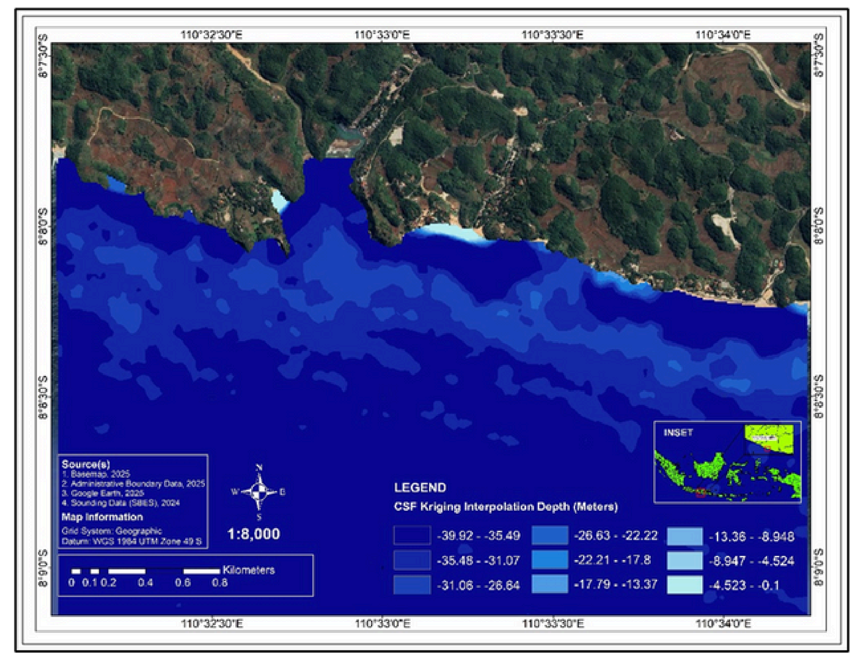
$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(At-Ft)^2}{n}}$$



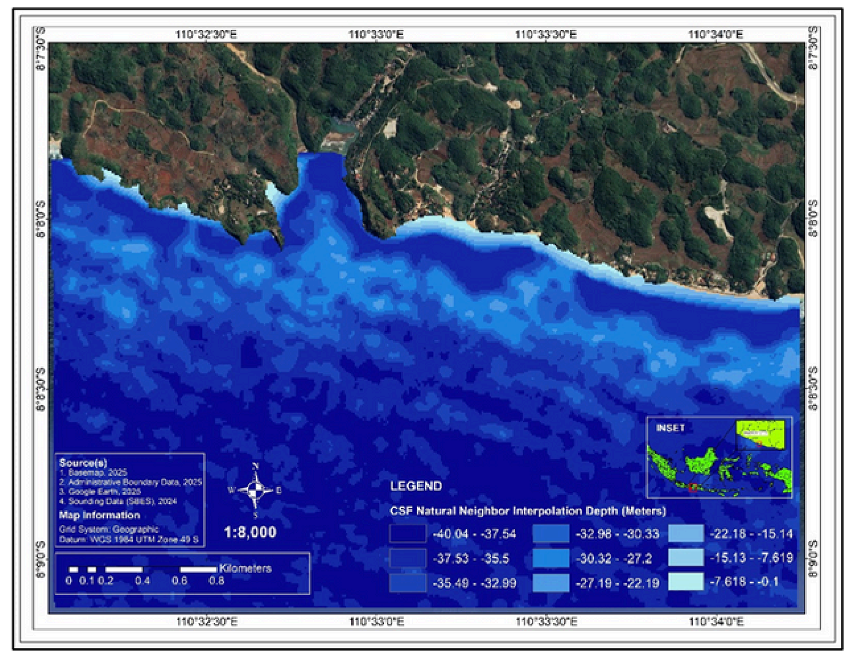
CSF + IDW Interpolation Map



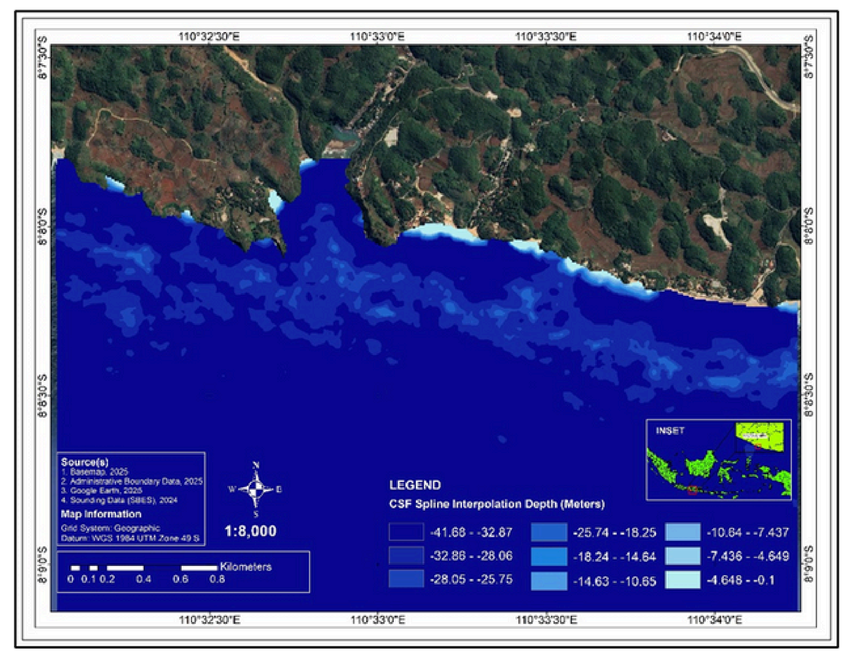
CSF + Kriging Interpolation Map



CSF + NN Interpolation Map



CSF + Spline Interpolation Map



Results

The best result was achieved by CSF + IDW (R^2 = 0.453; RMSE = 1.619 m), showing a significant improvement compared to the initial green band model (R^2 = 0.211; RMSE = 2.080 m)

Table 1: Statistical Performance of Initial and Optimised Models

Model	R	R2	RMSE (m)
Initial Green Band	0.46	0.211	2.08
CSF + IDW	0.673	0.453	1.619 ✔
CSF + Kriging	0.67	0.449	1.626
CSF + Natural	0.642	0.412	1.674
CSF + Spline	0.669	0.448	1.625

Analysis

The application of CSF was effective in filtering out noise caused by turbidity, surface ripples, and seabed heterogeneity, while preserving key morphological features (Zhang et al., 2016). IDW performed best due to its suitability for dense point distributions, such as the SBES data at Baron Beach. Kriging provided detailed results but was highly sensitive to uneven data spacing. Spline tended to oversmooth, and Natural Neighbour lacked detail. The best result (CSF + IDW) reached IHO Order 1, making it reliable for coastal mapping, though not yet sufficient for high-precision navigation (IHO, 2022).

Conclusion

This study demonstrates that integrating single-band regression, CSF filtering, and spatial interpolation can significantly improve the accuracy of PlanetScope-based SDB. The CSF + IDW model reduced RMSE by 0.461 m and increased R^2 by 0.242, showing substantial improvement over the initial regression. This method is efficient and cost-effective for shallow tropical waters. Future research should explore multi-band approaches, machine learning algorithms, and applications in other coastal regions

Key Sources

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