

**ANALISIS MULTITEMPORAL CITRA SENTINEL-2A
UNTUK ESTIMASI STOK KARBON ATAS PERMUKAAN MANGROVE
DI *CLUNGUP MANGROVE CONSERVATION* (CMC),
KABUPATEN MALANG TAHUN 2017, 2021, DAN 2025**

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ABSTRAK

Hutan mangrove berperan penting dalam mitigasi perubahan iklim melalui kemampuannya menyerap dan menyimpan karbon, terutama dalam bentuk *Above-Ground Carbon* (AGC). Namun, tingginya tingkat degradasi mangrove di Indonesia menyebabkan penurunan kapasitas penyimpanan karbon dan berpotensi meningkatkan emisi CO₂ di atmosfer. Penelitian ini bertujuan untuk memetakan distribusi dan mengestimasi nilai AGC mangrove di kawasan *Clungup Mangrove Conservation* pada tahun 2025. Selain itu, penelitian ini juga menganalisis perubahan spasio-temporal stok karbon atas permukaan mangrove selama periode 2017, 2021, dan 2025. Model AGC dibangun menggunakan hubungan antara hasil pengukuran lapangan dan indeks vegetasi dari citra Sentinel-2A. Indeks *Simple Ratio* dengan algoritma *Random Forest Regressor* dipilih sebagai model terbaik dengan nilai R^2 sebesar 0,76 dan RMSE sebesar 0,14 ton C/piksel. Hasil pemetaan tahun 2025 menunjukkan bahwa kawasan mangrove di *Clungup Mangrove Conservation* didominasi oleh kelas AGC tinggi, terutama pada bagian barat kawasan yang merupakan zona mangrove alami. Analisis multitemporal periode 2017, 2021, dan 2025 menunjukkan bahwa perubahan AGC didominasi oleh kondisi stabil dan meningkat, dengan luasan penurunan yang relatif kecil dibandingkan area yang mengalami peningkatan. Total stok karbon juga mengalami kenaikan dari 2.085 ton pada 2017 menjadi 2.686 ton pada 2025. Hasil ini menunjukkan bahwa kondisi mangrove di kawasan penelitian mengalami perkembangan positif karena proses konservasi dan berpotensi mendukung peningkatan stok karbon di masa mendatang.

Kata Kunci : Mangrove, *Above-Ground Carbon*, Stok Karbon, Multitemporal, Sentinel-2A, *Clungup Mangrove Conservation*

**MULTITEMPORAL ANALYSIS OF SENTINEL-2A IMAGERY
FOR ESTIMATING MANGROVE ABOVE-GROUND CARBON STOCK
IN CLUNGUP MANGROVE CONSERVATION (CMC),
MALANG REGENCY, 2017, 2021, AND 2025**

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ABSTRACT

Mangrove forests play an important role in climate change mitigation through their ability to absorb and store carbon, particularly in the form of Above-Ground Carbon (AGC). However, the high rate of mangrove degradation in Indonesia has reduced carbon storage capacity and has the potential to increase CO₂ emissions into the atmosphere. This study aims to map the distribution and estimate the AGC value of mangroves in the Clungup Mangrove Conservation area in 2025. In addition, this study analyzes the spatio-temporal changes in above-ground carbon stock of mangroves during the 2017, 2021, and 2025 period. The AGC model was developed using the relationship between field measurement results and vegetation indices derived from Sentinel-2A imagery. The Simple Ratio index with the Random Forest Regressor algorithm was selected as the best model, with an R² value of 0.76 and an RMSE value of 0.14 tons C/pixel. The 2025 mapping results show that the mangrove area in Clungup Mangrove Conservation is dominated by high AGC classes, particularly in the western part of the area, which is characterized as a natural mangrove zone. The multitemporal analysis for the 2017–2025 period indicates that AGC changes were dominated by stable and increasing conditions, while the area experiencing decline was relatively small compared to the area showing an increase. Total carbon stock also increased from 2,085 tons in 2017 to 2,686 tons in 2025. These results indicate that the mangrove condition in the study area has shown positive development due to conservation efforts and has the potential to support greater carbon stock in the future.

Keywords : Mangrove, Above-Ground Carbon, Carbon Stock, Multitemporal, Sentinel-2A, Clungup Mangrove Conservation