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Aulya Ulin Nuha[1], Ris Hadi Purwanto[2], Bekti Larasati[2]

INTISARI

Perubahan iklim dan peningkatan emisi karbon mendorong perlunya informasi cadangan karbon hutan yang akurat. Potensi *Carbon Trading* termasuk pada kawasan dengan persetujuan perhutanan sosial sudah memiliki dasar hukum sehingga diperlukan informasi cadangan karbon sebagai referensi. Penelitian ini bertujuan untuk mengembangkan model estimasi cadangan karbon berbasis data spasial multivariabel pada areal KHDPK dengan Persetujuan Perhutanan Sosial dengan skema Hutan Kemasyarakatan (HKm) di Desa Wonocoyo. Dalam penelitian ini, diterapkan juga metode seleksi fitur untuk memilih variabel – variabel paling berpengaruh dalam model. Selanjutnya, pemodelan dilakukan menggunakan beberapa pendekatan regresi dan *Machine Learning* dengan evaluasi performa melalui 20-fold *Cross Validation* berdasarkan nilai koefisien determinasi (R^2), *root mean square error* (RMSE), dan *mean absolute error* (MAE). Hasil penelitian menunjukkan bahwa Band spektral, indeks vegetasi, tekstur citra, dan topografi merupakan prediktor paling berpengaruh terhadap estimasi cadangan karbon. Model terbaik diperoleh pada *Model Machine Learning* dengan *Feature Selection Boruta* yang menghasilkan nilai CV R^2 sebesar 0,78, CV RMSE sebesar 25,79, dan CV MAE sebesar 21,33. Hasil penelitian menunjukkan bahwa metode *Machine Learning* dengan metode seleksi fitur *Boruta* mampu menghasilkan kombinasi variabel Band 3, Band 4, Band 5, NDVI dan ARVI yang paling optimal dalam meningkatkan akurasi estimasi cadangan karbon di KHDPK dengan Persetujuan Perhutanan Sosial HKm Wonocoyo. Estimasi cadangan karbon KHDPK HKm Wonocoyo menunjukkan hasil total stok karbon sebesar 21.567,36 ton C dengan rata-rata 45,12 ton C/ha yang tergolong dalam kategori sedang.

Kata Kunci: Cadangan Karbon, Penginderaan Jauh, Seleksi Fitur, Regresi Statistik, Pembelajaran Mesin

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CARBON STOCK MODELING USING MULTIVARIABLE SPATIAL DATA IN WONOCOYO COMMUNITY FOREST

Aulya Ulin Nuha[1], Ris Hadi Purwanto[2], Bekti Larasati[2]

ABSTRACT

Climate change and increasing carbon emissions have highlighted the importance of accurate forest carbon stock information. The potential implementation of carbon trading in social forestry areas is supported by an established legal framework, creating a need for reliable carbon stock data as a reference for carbon-based environmental services. This study aimed to develop a forest carbon stock estimation model in the KHDPK Social Forestry HKm Wonocoyo area using the integration of multivariable spatial data. Feature Selection methods were applied to identify the most influential variables affecting carbon stock estimation. Subsequently, statistical Regression and Machine Learning approaches were employed, and model performance was evaluated using 20-fold cross-validation based on the Coefficient of Determination (R^2), Root Mean Square Error (RMSE), and Mean Absolute Error (MAE). The results indicated that spectral bands, vegetation indices, image texture, and topographic variables were important predictors of forest carbon stock. The best model performance was achieved by the Machine Learning approach using Boruta Feature Selection combined with an Artificial Neural Network (ANN), which produced a CV R^2 value of 0.78, CV RMSE of 25.79, and CV MAE of 21.33. The selected variables consisted of Band 3, Band 4, Band 5, NDVI, and ARVI, indicating that spectral and vegetation-related variables played a dominant role in carbon stock estimation. The findings demonstrate that the Machine Learning approach combined with the Boruta Feature Selection method provided the most optimal variable combination for improving carbon stock estimation accuracy in the KHDPK Social Forestry HKm Wonocoyo area. The estimated carbon stock in KHDPK Social Forestry HKm Wonocoyo reached 21,567.36 tons C, with an average carbon stock of 45.12 tons C ha^{-1}, which falls within the moderate carbon stock category.
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Keywords: *Carbon Stock, Remote Sensing, Feature Selection, Statistic Regression, Machine Learning*

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