Pendugaan Simpanan Karbon di Areal Reklamasi Grasberg PT. Freeport Indonesia Menggunakan Pendekatan *Hybrid Remote Sensing* dan *Machine Learning*

(*Estimating Carbon Storage in the Grasberg Reclamation Area of PT. Freeport Indonesia Using a Hybrid Remote Sensing and Machine Learning Approach*)

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ABSTRACTS

The complexity of post-mining land restoration and reclamation dynamics requires robust monitoring techniques to produce accurate information. One potential approach to monitoring techniques is remote sensing and the combined application of machine learning, which has been shown to improve estimation accuracy. The purpose of this study is to estimate the biomass and carbon storage of vegetation in the Grasberg reclamation area of PT. Freeport Indonesia using remote sensing and machine learning approaches. The application of machine learning through Artificial Neural Network (ANN) algorithm uses 8 GLCM texture feature variables consisting of Contrast, Dissimilarity, Homogeneity, Angular Second Moment, Entrophy, Mean, Variance, and Correlation. The results show that the ANN architecture model is very good at estimating vegetation potential in the Grasberg reclamation area of PT. Freeport Indonesia with the coefficient of determination (R^2), Root Mean Square Error (RMSE), and RMSE Observations Standard Deviation ratio (RSR) of 0.86; 7.05; and 0.37, respectively. The estimated biomass of vegetation in the Grasberg reclamation area of PT. Freeport Indonesia is 824.78 tons with an average of 2.26 tons/ha with an area of 364.4 Ha of Grasberg reclamation area and the amount of aboveground carbon stored is 387.64 tons with an average of 1.06 tons/ha.

KEYWORDS
Reclamation, Remote Sensing, Artificial Neural Network, Biomass, Carbon

INTISARI

Kompleksitas dari dinamika restorasi dan reklamasi lahan pasca tambang memerlukan teknik monitoring yang kuat untuk menghasilkan informasi yang akurat. Salah satu pendekatan yang potensial dalam teknis monitoring yaitu penginderaan jauh dan kombinasi penerapan *machine learning* yang terbukti dapat meningkatkan akurasi pendugaan. Tujuan dari penelitian ini yaitu menduga biomassa dan simpanan karbon vegetasi di areal reklamasi Grasberg PT. Freeport Indonesia menggunakan pendekatan penginderaan jauh dan *machine learning*. Penerapan machine learning melalui algoritma Artificial Neural Network (ANN) menggunakan 8 variabel fitur tekstur GLCM yang terdiri dari *Contrast*, *Dissimilarity*, *Homogenity*, *Angular Second Moment*, *Entrophy*, *Mean*, *Variance*, dan *Correlation*. Hasil penelitian menunjukkan bahwa model arsitektur ANN sangat baik dalam menduga simpanan karbon di areal reklamasi Grasberg PT. Freeport Indonesia dengan nilai koefisien determinasi (R^2), *Root Mean Square Error* (RMSE), dan *RMSE Observations Standard Deviation ratio* (RSR) secara berturut-turut sebesar 0,86; 7,05; dan 0.37. Hasil pendugaan biomassa vegetasi di areal reklamasi Grasberg PT. Freeport Indonesia sebesar 824,78 ton dengan rata-rata sebesar 2,26 ton/ha dengan luas areal reklamasi Grasberg sebesar 364.4 Ha dan besarnya cadangan karbon di atas permukaan tanah yang tersimpan sebesar 387,64 ton dengan rata-rata 1,06 ton/ha.

KATA KUNCI
Reklamasi, *Penginderaan Jauh*, *Artificial Neural Network*, Biomassa, Karbon