

INTISARI

Perubahan tutupan hutan akibat deforestasi dan degradasi merupakan faktor utama yang memengaruhi keberlanjutan pengelolaan ekosistem hutan. Tekanan pembangunan dan peningkatan aktivitas antropogenik berpotensi membuka akses ke kawasan hutan, sehingga diperlukan pemantauan hutan secara berkala. Pemantauan tersebut memerlukan metode yang mampu mendeteksi dinamika vegetasi secara konsisten dan jangka panjang. Penelitian ini bertujuan untuk mengidentifikasi area indikatif deforestasi dan degradasi, mengevaluasi kemampuan algoritma *Cumulative Sum (CuSum)*, serta menyajikan hasil analisis dalam bentuk aplikasi berbasis Google Earth Engine (GEE-Apps).

Penelitian menggunakan citra *Synthetic Aperture Radar (SAR)* Sentinel-1 periode tahun 2015 - 2025 di kawasan hutan Gunung Lawu. Tahapan metode penelitian meliputi normalisasi citra *SAR* Sentinel-1, ekstraksi nilai hamburan, analisis perubahan temporal menggunakan algoritma *Cumulative Sum*, pengujian perubahan tingkat keyakinan dengan *Bootstrap Analysis*, serta klasifikasi area menjadi indikatif deforestasi, degradasi, dan tidak mengalami perubahan tutupan hutan. Evaluasi hasil dilakukan melalui penghitungan akurasi menggunakan pendekatan *random stratified sampling* dengan data referensi yang diperoleh dari survei lapangan, interpretasi citra resolusi tinggi (Google Earth), dan data sekunder.

Hasil penelitian menunjukkan bahwa *Cumulative Sum* mampu mengidentifikasi area yang mengalami perubahan tutupan hutan dengan nilai *Overall Accuracy* sebesar 70,77%. Hasil uji usability melalui pengujian sistem memperoleh nilai rata-rata 82,15% dengan aspek fungsi analisis spasial memiliki persentase tertinggi, disusul dengan aspek navigasi dan kemudahan pengguna, kepuasan dan potensi pengembangan, serta efisiensi sistem. Pola perubahan tutupan hutan terdeteksi memiliki pola spasial terlokalisasi dengan tren perubahan yang sebagian besar terjadi pada musim kemarau dibandingkan musim hujan. Penelitian ini menunjukkan bahwa pendekatan analisis deret waktu dengan *Cumulative Sum* berpotensi mendukung pemantauan perubahan tutupan hutan secara temporal menggunakan *SAR* Sentinel-1. Nilai akurasi model masih dapat ditingkatkan dengan mengombinasikan data multi-sensor, citra resolusi lebih tinggi, dan perluasan data referensi validasi.

Kata kunci: *Cumulative Sum*, Sentinel-1, deforestasi, degradasi, GEE-Apps

ABSTRACT

Forest cover change resulting from deforestation and degradation is one of the primary factors affecting the sustainability of forest ecosystem management. Increasing development pressures and anthropogenic activities have potentially expanded access to forest areas, highlighting the need for continuous and systematic forest monitoring. Such monitoring requires methods capable of consistently detecting vegetation dynamics over long time periods. This study aims to identify indicative areas of deforestation and degradation, evaluate the performance of the Cumulative Sum (CuSum) algorithm, and present the analytical results through a Google Earth Engine-based application (GEE-Apps).

The study utilized Synthetic Aperture Radar (SAR) Sentinel-1 imagery acquired between 2015 and 2025 over the Mount Lawu forest area. The research methodology consisted of Sentinel-1 SAR image normalization, backscatter value extraction, temporal change analysis using the Cumulative Sum algorithm, confidence level assessment through Bootstrap Analysis, and classification of areas into indicative deforestation, degradation, and unchanged forest cover categories. The results were evaluated using an accuracy assessment based on a random stratified sampling approach, with reference data obtained from field surveys, high-resolution image interpretation (Google Earth), and secondary data sources.

The results demonstrate that the Cumulative Sum algorithm is capable of identifying areas experiencing forest cover change, achieving an Overall Accuracy of 70,77%. Usability testing of the developed system yielded an average score of 82,15%, with spatial analysis functionality receiving the highest rating, followed by navigation and user-friendliness, user satisfaction and development potential, and system efficiency. The detected forest cover changes exhibited localized spatial patterns, with most changes occurring during the dry season rather than the rainy season. These findings indicate that the Cumulative Sum-based time-series analysis approach has considerable potential for supporting temporal forest cover monitoring using Sentinel-1 SAR data. Nevertheless, the model accuracy could be further improved through the integration of multi-sensor datasets, higher-resolution imagery, and a more extensive set of validation reference data.

Keywords: Cumulative Sum, Sentinel-1, deforestation, degradation, GEE-Apps