INTISARI

Penilaian kerentanan fisik bangunan terhadap longsor melalui pendekatan indikator umumnya dilakukan menggunakan teknik sensus, seperti survei lapangan atau interpretasi foto udara, yang memiliki sejumlah keterbatasan. Teknik sensus memerlukan sumber daya waktu dan tenaga kerja yang tinggi, sedangkan interpretasi foto udara berpotensi menghasilkan bias akibat subjektivitas dalam analisis. Selain itu, pendekatan-pendekatan tersebut jarang mempertimbangkan tingkat eksposur berupa intensitas longsor secara langsung. Sebagai alternatif, penelitian ini mengusulkan pendekatan berbasis data *point cloud* LiDAR *airborne* untuk memberikan hasil yang lebih efisien, akurat, dan konsisten dalam mengidentifikasi indikator kerentanan bangunan, sekaligus memperhitungkan tingkat eksposur berupa intensitas longsor.

Tujuan dari penelitian ini adalah (1) mengekstraksi indikator kerentanan fisik bangunan dari data *point cloud* LiDAR *airborne*, (2) menilai kerentanan fisik bangunan terhadap longsor dan (3) mengetahui distribusi spasial kerentanan spesifik lokasi di ruas Jalan Salaman-Bener, Kabupaten Magelang. Tahapan pengolahan meliputi akuisisi data LiDAR serta pengolahan data *point cloud* menjadi *Digital Terrain Model* (DTM), *Digital Surface Model* (DSM), dan model 3D bangunan *Level of Detail 2* (LoD2). Model 3D bangunan LoD2 digunakan untuk mendukung ekstraksi indikator kerentanan. Kerentanan fisik bangunan (PV) dihitung menggunakan fungsi hubungan antara intensitas longsor (I) dan ketahanan bangunan (R). Intensitas longsor dihitung berdasarkan matriks hubungan volume dan kecepatan longsor. Indikator tipologi struktur (R1), bentuk bangunan horizontal (R2) dan vertikal (R3), dan orientasi bangunan (R4) digunakan untuk menilai ketahanan bangunan. Indikator jarak terhadap sumber longsor (P) digunakan untuk menilai kerentanan spesifik lokasi (SSV).

Hasil analisis menunjukkan intensitas longsor di area penelitian masuk dalam kategori "tinggi" dengan nilai I = 0,8 dan "sedang" dengan nilai I = 0,4. Terdapat 98 bangunan di jalur lintasan *run-out* longsor, sebanyak 33% masuk kelas kerentanan tinggi/III (kerusakan sangat berat hingga total), 63% kelas sedang/II (kerusakan sedang-berat), dan 4% kelas rendah/I (kerusakan ringan). Data *point cloud* LiDAR *airborne* terbukti efektif dalam menilai kerentanan bangunan terhadap longsor dan model 3d LoD2 dapat digunakan untuk mengekstraksi tipologi struktur (R1) dengan tingkat akurasi interpretasi sebesar 88%. Temuan ini memberikan landasan ilmiah untuk pengembangan strategi mitigasi yang lebih terukur dan berbasis data dalam upaya mengurangi kerusakan bangunan akibat bahaya longsor, yang dapat berdampak langsung pada keselamatan jiwa.

Kata kunci: Kerentanan fisik bangunan, intensitas longsor, LiDAR, LoD2

ABSTRACT

The assessment of building physical vulnerability to landslides using indicator-based approaches is typically conducted through census techniques, such as field surveys or aerial photo interpretation, which have several limitations. Census techniques require significant time and labor resources, while aerial photo interpretation is prone to bias due to subjective analysis. Furthermore, these approaches rarely consider direct exposure levels, such as landslide intensity. As an alternative, this study proposes an airborne LiDAR point cloud-based approach to provide more efficient, accurate, and consistent results in identifying building vulnerability indicators while accounting for exposure levels in terms of landslide intensity.

The objectives of this study are to (1) extract building physical vulnerability indicators from airborne LiDAR point cloud data, (2) assess building physical vulnerability to landslides, and (3) analyze the spatial distribution of site-specific vulnerability along the Salaman-Bener Road, Magelang Regency. The methodology includes LiDAR data acquisition and processing to generate a Digital Terrain Model (DTM), Digital Surface Model (DSM), and Level of Detail 2 (LoD2) 3D building models. The LoD2 3D building models support the extraction of structural vulnerability indicators. Building physical vulnerability (PV) is calculated using a relationship function between landslide intensity (I) and building resistance (R). Landslide intensity is determined based on a matrix of volume and velocity relationships. Structural typology (R1), horizontal (R2) and vertical (R3) building shapes, and building orientation (R4) are used to assess building resistance. Proximity to landslide sources (P) is used to evaluate site-specific vulnerability (SSV).

The analysis results show that landslide intensity in the study area is categorized as "high" (I = 0.8) and "moderate" (I = 0.4). A total of 98 buildings are located within the landslide run-out path, with 33% classified as high vulnerability (class III, severe to total damage), 63% as moderate vulnerability (class II, moderate to severe damage), and 4% as low vulnerability (class I, minor damage). Airborne LiDAR point cloud data proved effective in assessing building vulnerability to landslides, with LoD2 models achieving 88% accuracy in structural typology (R1) extraction. These findings provide a scientific basis for developing more data-driven and measurable mitigation strategies to reduce building damage and enhance life safety in landslide-prone areas.

Keywords: Building physical vulnerability, landslide Intensity, LiDAR, LoD2