ABSTRACT

The coastal area of Parangtritis, Yogyakarta Special Region, is highly vulnerable to tsunami hazards, facing challenges such as limited shelter capacity, high tourist density, and uneven evacuation access. This study develops a multi-objective optimization model using the Non-dominated Sorting Genetic Algorithm II (NSGA-II) combined with the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) for decision-making. The model employs three objective functions: minimizing evacuation time, balancing refugee distribution, and optimizing shelter utilization. Evaluation was conducted through 27 combinations of NSGA-II parameters (population size, crossover, and mutation rates) and multiple disaster scenarios representing dynamic field conditions, including road closures, reduced shelter capacity, and sudden surges in evacuees. The results indicate that the best parameter combination yields a well-converged and diverse Pareto front. In the baseline scenario, the optimal solution achieves an evacuation time of 3952.45 seconds, a refugee distribution variance of 1331.30, and shelter utilization of 52.28%. Under an extreme scenario (12,000 evacuees and only five shelters), the model remains robust, achieving a distribution variance of 348.31 and shelter utilization of 73.30%. These findings demonstrate that integrating NSGA-II with TOPSIS produces adaptive, data-driven evacuation strategies that align with policymakers' needs. The proposed model can serve as a decision-support tool for disaster evacuation planning in coastal areas with limited resources..

Keywords : *Optimization, Multi-Objective, Disaster Evacuation, NSGA-II and TOPSIS*

INTISARI

Wilayah pesisir Parangtritis di Daerah Istimewa Yogyakarta memiliki kerentanan tinggi terhadap bencana tsunami, dengan tantangan berupa keterbatasan kapasitas shelter, kepadatan wisatawan, dan akses evakuasi yang tidak merata. Penelitian ini mengembangkan model optimasi multi-objektif menggunakan algoritma Non-dominated Sorting Genetic Algorithm II (NSGA-II) yang dikombinasikan dengan metode pengambilan keputusan Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Tiga fungsi objektif digunakan dalam model, yaitu meminimalkan waktu tempuh evakuasi, memeratakan distribusi pengungsi, dan mengoptimalkan utilisasi shelter. Evaluasi dilakukan melalui 27 kombinasi parameter NSGA-II (ukuran populasi, probabilitas crossover, dan mutasi) dan beberapa skenario kebencanaan yang merepresentasikan kondisi dinamis lapangan, seperti penutupan akses jalan, pengurangan kapasitas shelter, dan lonjakan pengungsi. Hasil penelitian menunjukkan bahwa kombinasi parameter terbaik mampu menghasilkan Pareto front yang konvergen dan beragam, dengan solusi terbaik pada skenario baseline memiliki waktu tempuh 3952,45menit, variansi distribusi pengungsi 1331,30, dan utilisasi shelter 52,28%. Pada skenario ekstrem (12.000 pengungsi dan lima shelter), model tetap menunjukkan ketahanan dengan variansi distribusi 348,31 dan utilisasi shelter 73,30%. Temuan ini membuktikan bahwa integrasi NSGA-II dan TOPSIS dapat menghasilkan strategi evakuasi berbasis data yang adaptif dan sesuai kebutuhan pemangku kebijakan. Model yang dikembangkan dapat digunakan sebagai alat bantu pengambilan keputusan dalam perencanaan evakuasi bencana di kawasan pesisir dengan berbagai keterbatasan sumber daya.

Kata kunci -- Optimasi, Multi-Objektif, Evakuasi Bencana, NSGA-II dan TOPSIS