INTISARI

Layanan *on-demand food delivery* (ODFD) terus tumbuh didorong dengan pesatnya perkembangan teknologi dan internet yang memberikan kenyamanan bagi pelanggan untuk memesan makanan dari restoran dan mengirimnya sampai ke tangan mereka. Namun, pesatnya pertumbuhan bisnis ODFD tersebut berkontribusi dalam peningkatan jumlah kendaraan dan rute perjalanan khususnya di daerah perkotaan. Peningkatan jumlah kendaraan berdampak pada terjadinya kemacetan, peningkatan biaya, dan dampak lingkungan yang dapat menurunnya tingkat efisiensi sistem rantai pasok.

Penggunaan *drone* dapat menjadi salah satu solusi untuk mengatasi permasalahan tersebut. Akan tetapi, keterbatasan jangkauan terbang menjadi tantangan penggunaan *drone*. Oleh karena itu, dalam penelitian ini dikembangkan algoritma untuk menentukan lokasi *drone battery swapping station* agar dapat memaksimalkan cakupan layanan. Metode optimasi yang digunakan dalam algoritma berupa *ant colony optimization*. Sementara itu, pengujian algoritma menggunakan studi kasus area dalam Ring Road Yogyakarta, dengan jaringan jalan OpenStreetMap sebagai sumber data. Selain itu, dalam penelitian ini juga dibangun tiga skenario untuk mengidentifikasi pengaruh moda pengiriman yang digunakan terhadap rute dan dampak lingkungan yang dihasilkan.

Hasil optimasi lokasi fasilitas *battery swapping station* menunjukkan total cakupan *demand* sebesar 22357 titik atau 93,56% dari total titik *potential demand* yang ada. Sementara itu, hasil optimasi rute dengan total waktu pengiriman sebagai fungsi tujuan untuk ketiga skenario moda pengiriman berupa drone jangkauan 2 km, drone jangkauan 4 km, dan sepeda motor, berturut-turut, yaitu rata-rata selama 24,42 menit, 16,8 menit, dan 9,93 menit per pengiriman. Sedangkan, hasil perhitungan dampak lingkungan dengan skenario yang sama, terbagi menjadi tiga sesuai dengan indikator yang digunakan. Dampak lingkungan per pengiriman dengan indikator *global warming potential* (GWP) diperoleh nilai rata-rata sebesar $7{,}336 \times 10^{-2}$, $5{,}764 \times 10^{-1}$, $6{,}377 \times 10^{-1}$. Selanjutnya, dampak lingkungan per pengiriman dengan indikator *acidification potential* (AP) diperoleh nilai rata-rata sebesar $4{,}076 \times 10^{-4}$, $3{,}202 \times 10^{-3}$, $1{,}528 \times 10^{-3}$. Terakhir, dampak lingkungan per pengiriman dengan indikator *abiotic depletion potential* (ADP) diperoleh nilai rata-rata sebesar $1{,}592 \times 10^{-4}$, $1{,}250 \times 10^{-3}$, $4{,}717 \times 10^{-6}$.

Kata kunci: *On-demand food delivery*; *drone battery swapping stations*; *facility location problem*; sistem informasi geografis; *routing problem*; dampak lingkungan

ABSTRACT

On-Demand Food Delivery (ODFD) services have witnessed significant growth, driven by advancements in technology and internet accessibility. This has facilitated consumer convenience by enabling food orders from restaurants to be delivered directly to their doorstep. However, this rapid expansion has contributed to an increase in vehicular traffic and associated travel routes, particularly within urban areas. This surge in vehicle usage has resulted in traffic congestion, higher costs, and environmental impacts, ultimately hindering the efficiency of the supply chain system.

The utilization of drones presents a promising solution to overcome those challenges. However, their limited flight range poses a significant obstacle to widespread implementation. To address this limitation, this research focuses on developing an algorithm to optimize the location of drone battery swapping stations, thereby maximizing service coverage. Ant Colony Optimization is used as the optimization method within the algorithm. A case study is conducted within the Yogyakarta Ring Road area, utilizing OpenStreetMap as the data source, to evaluate the algorithm's performance. Furthermore, three distinct delivery vehicle scenarios are established: drones with a 2 km range, drones with a 4 km range, and motorcycles. These scenarios are implemented to assess the influence of vehicle types on delivery routes and environmental impact.

The optimization results of the location of the battery swapping station facility show a demand coverage of 22357 points, representing 93.56% of the total potential demand points. Meanwhile, the optimized routes with total delivery time as objective function for each delivery scenario – drones with a 2 km range, drones with a 4 km range, and motorcycles – are determined to be 24,42 minutes, 16,8 minutes, and 9,93 minutes, respectively, per delivery. Whereas the results of environmental impact assessments with the same scenario are divided based on three indicators: Global Warming Potential (GWP), Acidification Potential (AP), and Abiotic Depletion Potential (ADP). The value of environmental impact per delivery associated with GWP is calculated to be $7{,}336 \times 10^{-2}$, $5{,}764 \times 10^{-1}$, $6{,}377 \times 10^{-1}$ for each scenario, respectively. Similarly, the value of environmental impact per delivery associated with AP is determined to be $4{,}076 \times 10^{-4}$, $3{,}202 \times 10^{-3}$, $1{,}528 \times 10^{-3}$, respectively. Finally, the value of environmental impact per delivery associated with ADP is found to be $1{,}592 \times 10^{-4}$, $1{,}250 \times 10^{-3}$, $4{,}717 \times 10^{-6}$, respectively.

Keywords: On-demand food delivery; drone battery swapping stations; facility location problem; geographic information system; routing problem; environmental impact