Optimizing Bali's Eco-Tourism through Genetic Algorithm Integer Programming for Sustainable Travel Itineraries

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Abstrak

Studi ini adalah mengenai model optimisasi untuk mendesain *travel itinerary* untuk *eco-tourism* di Bali menggunakan *Integer Programming* dalam Algoritma Genetika. Fungsi Objektif mengintegrasikan berbagai komponen seperti preferensi pengguna, penalti lingkungan dan logistik, dan biaya perjalanan. Dengan menerjemahkan berbagai rute perjalanan sebagai kromosom berbasis integer, algoritma ini dapat mencari kombinasi itinerer yang menyeimbangkan keberlanjutan, personalisasi serta harga berkunjung. Model ini diimplementasikan pada dataset objek wisata yang ada si Bali. *Output* daripada algoritma ini memberi hasil yang optimal, beragam dan mendukung upaya *Eco-Tourism* di Bali. Hasil yang diperoleh merupakan itinerer yang praktis dan menarik, dengan mengimplementasikan keseimbangan antara keinginan user serta kebertanggungjawaban terhadap lingkungan. Penemuan dari studi ini memperlihatkan potensial dari optimisasi metaheuristic dalam mendukung perkembangan *Eco-Tourism* dan perencanaan tujuan salam pariwisata.

Kata kunci: eco-tourism, genetic algorithm, interger programming, travel itenerary optimization, sustainable tourim

Abstract

This study presents an optimization model for designing sustainable travel itineraries in Bali's eco-tourism sector using a Genetic Algorithm-based Integer Programming approach. The objective function integrates multiple components, including traveler preferences, environmental and logistical penalties, and overall travel costs. By encoding travel routes as integer-based chromosomes, the algorithm efficiently explores potential itinerary combinations to identify solutions that balance personalization, sustainability, and cost-effectiveness. The model is implemented on a curated dataset of eco-tourism destinations across Bali, incorporating real-world constraints such as travel time, location clustering, and eco-impact indicators. The resulting itineraries are analyzed based on optimality, diversity, and alignment with sustainability goals. Results demonstrate that the proposed approach generates practical and appealing travel plans, which despite its limitations manages to find a good balance between user's needs and sustainability.

Keywords: eco-tourism, genetic algorithm, interger programming, travel itenerary optimization, sustainable tourim

1. Introduction

The tourism industry is a vital pillar of Indonesia's economy, contributing significantly to national income and international recognition. Ranked 32nd among 117 countries for overall tourism performance and second globally in the halal tourism sector, Indonesia demonstrates a strong and diverse tourism appeal. However, the COVID-19 pandemic caused a substantial contraction in tourism's contribution to GDP, dropping from 5.2% in 2019 to 3.6% in 2022 [1]. This downturn highlights the urgent need for adaptive strategies to revitalize and future-proof the tourism sector, particularly through data-driven and sustainable innovations.

A key area for such innovation lies in enhancing travel planning through comprehensive tourism information services. Modern travelers seek curated and reliable