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 information on Points of Interest (POIs)—including key destinations, travel costs, cultural experiences, accommodation options, transportation access, and local climate. These elements are foundational to constructing effective and personalized travel itineraries. Addressing the challenges of gathering and maintaining such data, two main strategies have emerged: direct integration of POI data from individual sites and enrichment of publicly available online resources [2]. The latter approach offers greater efficiency and scalability in dynamic tourism environments.

To further improve travel experiences, the Tourist Travel Design Problem (TTDP) has been formulated as a combinatorial optimization challenge, requiring algorithms capable of generating optimal travel routes within time, cost, and interest constraints [3]. Among various approaches, Genetic Algorithm Integer Programming particularly when integrated with methods such as Iterated Local Search, has shown promise in efficiently solving these complex, multi-criteria problems.

Motivated by these challenges and opportunities, this study focuses on Bali, one of Indonesia's premier eco-tourism destinations. The research aims to develop a sustainable and optimized travel itinerary system using Genetic Algorithm Integer Programming. The proposed model incorporates multiple decision factors, including user preferences, travel distances, carbon emission considerations, and logistical constraints, to generate personalized yet sustainable itineraries.

Furthermore, the study conducts an in-depth analysis of the resulting itineraries to evaluate their practicality, quality, and alignment with environmental sustainability goals. By doing so, this research contributes not only to improved itinerary planning but also to broader efforts in promoting responsible and eco-conscious tourism in Bali. The findings are expected to offer valuable insights into how computational optimization can support strategic tourism development in line with sustainable travel principles.

Background

Current state-of-the-art travel recommendation systems demonstrate various approaches to address tourism planning challenges. Garcia et al. [1] developed a multi-objective optimization framework for tourist trip planning using evolutionary algorithms, achieving significant improvements in solution quality but lacking geographical clustering considerations. Wang and Liu [2] proposed a collaborative filtering approach combined with location-based services for tourism recommendations, showing effectiveness in user preference matching but limited optimization for route efficiency. Chen et al. [3] implemented a hybrid recommendation system using machine learning techniques for tourism planning, demonstrating improved user satisfaction but requiring extensive computational resources. Kumar and Sharma [4] developed a time-aware tourism recommendation system considering temporal constraints, showing promising results in constraint satisfaction but limited scalability for large-scale POI datasets. Rodriguez and Martinez [5] presented a multi-criteria decision analysis framework for tourism itinerary planning, achieving balanced solutions but lacking real-time optimization capabilities.

Problem Statement

Despite these advances, existing systems exhibit significant limitations in simultaneously addressing geographical clustering, route optimization, and multiple constraint satisfaction for specific tourism destinations. The research gap lies in the lack of specialized systems that integrate efficient clustering algorithms with metaheuristic optimization techniques specifically designed for complex tourism ecosystems like Bali Province. This research addresses these limitations by developing a hybrid approach

combining K-means clustering for geographical grouping with Genetic Algorithm optimization for route planning, specifically tailored for Bali's unique tourism landscape. The research objectives include: (1) developing an efficient POI clustering mechanism based on geographical proximity, (2) implementing a specialized Genetic Algorithm for route optimization within clusters, and (3) creating a comprehensive system that generates personalized itineraries while satisfying multiple constraints.

From those descriptions, the author found several interesting problems to find solutions for in relation to tourism itineraries. These problems are:

1. How to effectively employ Genetic Algorithm (GA) for travel itinerary optimization, navigating various factors like transportation modes, carbon reduction, distance management, and user preferences.
2. How GA-Generated Itineraries are analyzed, to evaluate itineraries produced through GA, assessing their quality, feasibility, and alignment with environmental sustainability, user preferences, and tourism promotion.

Study Objectives

This research is intended to:

1. To proficiently utilize GA in optimizing travel itineraries, strategically navigating through diverse factors such as transportation modes, carbon reduction, distance management, and user preferences.
2. To analyze GA-generated itineraries, evaluating their quality, feasibility, and alignment with environmental sustainability, user preferences, and tourism promotion.