

Integrated Transportation Planning to Enhance Tourism Industry: A Case Study of Northeastern Thailand

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Abstract—The tourism sector connects travelers, tourist attractions, and services provided by affiliated tourism organizations. These factors are interconnected via logistics and transportation operations. Effective design of tourism networks is crucial for supporting travelers and augmenting revenue opportunities for any destination. It might enhance tourism and foster income-generating prospects for each site. This study uses transportation optimization techniques to identify the most effective approach to improving the tourism sector. The transportation planning models aim to minimize the overall travel distance to the locations and to determine routes that optimize the average rating score of attractions in the lower northeastern area of Thailand. The results of this study may assist governmental bodies and organizations in promoting travel routes and formulating plans to enhance the tourist sector in case study areas moving forward.

Keywords—tourism logistics, optimization, transportation network, shortest path

I. INTRODUCTION

Tourism is vital for regional economic development, fostering cultural exchange and encouraging sustainable living. It is among the rapidly expanding industries that serve as an increasingly essential source of revenue, employment, and wealth in several nations (Neto, 2003). The tourism business, viewed as a system, comprises three components: visitors, geographical factors (including destinations and transit routes), and industrial elements (such as transportation infrastructure, visitor attractions, and service providers) (Varvaressos, 2018). The tourists are motivated to undertake a leisure vacation, starting the process with selecting, preparing, and organizing, followed by arranging transportation to the place where the holiday is enjoyed. The tourist experiences encompass more than just the on-site experience (Middleton *et al.*, 2009). The key goal of the tourism industry is to fulfill the requirements of travelers according to their diverse preferences for transportation, activities, and attractions at minimal prices (Piya, 2023). Consequently, logistics management for the tourism sector, referred to as tourism logistics, is essential as it enables the design, implementation, and management of the flows of people, products, services, and necessary information to support tourist operations at the lowest cost or minimize transportation distance (Stipanovic and Rudan, 2014; Puchongkawarin and Ransikarbun, 2021). The primary role of tourism logistics involves the integration of decision-making and communication across various interconnected activities, such as coordinating transportation, accommodation, and excursions, and ensuring the smooth movement of visitors between destinations to enhance their utility and alleviate stress, thereby improving their overall

experience (Zhao and Hou, 2022).

Review articles indicate that most of the existing literature has developed mathematical models to optimize routes based on various objectives, such as minimizing travel distance for public transit to tourist destinations in Thailand (Puchongkawarin and Ransikarbun, 2021) and generating the optimal network flow for tourists and dental patients in Iran (Ahmadimanesh, 2019). Certain prior studies have suggested models that concurrently optimize the accessibility of areas of interest, reduce overall travel time, and minimize the number of intersections to address the cycle-tourist route-planning issue in Singapore (Zhu, 2022). A research study identified a popular vacation destination for organizing day trip routes among 48 potential attractions in China (Zheng, 2020). Tourism route planning has attracted considerable interest from scholars within the field of tourism logistics, and the study's results could offer a foundation for strategic advancement in the tourism industry.

This study utilizes network optimization models to determine the optimal approach for enhancing the tourist industry. The objectives of the models are to minimize the total travel distance to visit the destinations and to identify routes that maximize the average rating score of the attractions in the lower northeastern region of Thailand. The findings of this study may benefit the travel government and agencies in promoting travel routes and developing strategies to help the tourism business in the case study locations.

The subsequent sections of this paper are structured as follows: Section II presents an overview of the relevant literature. Section III explains the research approach. Section IV provides details on the case study region and results. Section V presents the conclusion and discussion.

II. LITERATURE REVIEW

In the age of globalization and post-pandemic recovery, the tourist sector significantly contributes to the economy and development of several countries. Consequently, the mobility of visitors, service integration, infrastructure, and lodging growth are the principal elements influencing the competitive advantage of the tourism business. In this context, logistics and transportation for managing the tourist sector, referred to as "tourism logistics," are key components that greatly contribute to economic growth. Inefficient administration of tourism and transportation may lead to economic problems (Puchongkawarin and Ransikarbun, 2021; Ngeoywijit *et al.*, 2022). In the past, several scholars have shown interest in tourist logistics. The most evident study pertained to the design of transportation networks and tourist trips through the application of optimization models. There is prior research employed the mixed method approach for determine the

optimal public transportation route with minimum overall distance for reaching tourism spots in Ubon Ratchathani province of Thailand in which the formulated mode was developed based on the traveling salesman approach (Puchongkawarin and Ransikarbum, 2021). Another research provided ideal tourism routes to visit shopping destinations to enhance the tourism of the agricultural product industry in Chiang Rai province of Thailand. The model concentrated on identifying the shortest routes while adhering to time frame limitations (Sirirak and Pitakaso, 2018). Tourism route design facilitates visitors' engagement with travel efficiently, promptly and securely. Defining the proper objective function can improve tourism logistics operation. Previous work modified the algorithm for addressing the transportation model by integrating the genetic algorithm with the Analytical Hierarchy Process (AHP). The hybrid algorithm was developed to identify an ideal tourism route that minimizes total cost, resource use, and overall distance. The relevance of this study was demonstrated by the case study of the tourist industry in Chengdu, China (Damos, 2021). Research has developed a model for cycle-tourist route design that concurrently assessed numerous objectives. Optimal routes are formulated to enhance the profitability of visiting each site, reduce overall travel duration, elevate the bicycle level of service, and minimize the number of junctions throughout the bike tour among the selected points of interest. The suggested model's applicability is validated using the tourist sector in Singapore (Zhu, 2022).

Besides assessing distance, time, cost, resource utilization, and the quantity of sites seen, tourists also prioritize the significance of tourism attractions. The experiential quality of their journey is an essential element in trip planning (Ram *et al.*, 2016). The tourism industry is characterized by consumers selecting travel locations based on comprehensive information derived from the experiences shared by previous visitors (Palang and Tippayawong, 2019). The travel experience is a crucial element in visitors' evaluations of a place and may also influence their tourism intentions. Adverse travel experiences diminish tourists' desire to return, but favorable travel experiences enhance word-of-mouth and the intention to revisit (Homsud, 2024). Thus, the site choices of visitors are frequently influenced by their satisfaction levels and the feelings expressed by other tourists who have evaluated and shared their experiences. Tourism perspectives are generally articulated via electronic word-of-mouth on social media, where customers convey their ideas (Ramos *et al.*, 2022; Mogaji and Erkan, 2019).

Traditional tourism route planning prioritizes the quickest path, sometimes neglecting the assessment of scenic road conditions and suggestions from prior travelers. Consequently, it is essential to select the optimal attractive route by thoroughly evaluating the qualitative characteristics of the picturesque area (Wang *et al.*, 2022). The literature review indicated that research often uses quantitative metrics to ascertain travel paths. Many studies continue to neglect the incorporation of satisfaction as criteria for determining optimal pathways. The application of research on the design of tourist routes in Thailand focuses mainly on public transport networks, whereas travel routes are predominantly reliant on private vehicles due to the underdevelopment of public transportation. Moreover, several studies are

conducted at the provincial level rather than the regional level. Their planning is uninfluenced by ratings, perhaps resulting in the oversight of prominent tourist destinations. Therefore, there remains an opportunity for enhancement by addressing the identified gap.

III. RESEARCH METHODOLOGY

The shortest path technique for optimizing the transportation network was developed to determine the optimal tourist route. The requisite data for formulating the models comprise the locations of attractions, referred to as nodes; the edges signify linkages, i.e., roads or networks connecting nodes; the distance between neighboring nodes is measured in kilometers; and the rating score of each node is determined by tourists' rankings.

A. Indices, Parameters, and Decision Variables

Let $G = (V, E)$ represent the graph where:

- V Set of nodes
- E Set of edges
- N Number of selected nodes
- d_{ij} Distance associated with edge $(i, j) \in E$
- r_j Rating score of destination j
- x_{ij} Binary decision variable

$$x_{ij} = \begin{cases} 1 & \text{if edge } (i, j) \text{ is a part of the shortest path,} \\ 0 & \text{otherwise} \end{cases}$$

B. Model 1 Route Optimization for Minimizing the Overall Distance among Travel Destinations

The objective function of the first model (Eq.1) is to minimize the overall distance among chosen locations. The constraint (Eq. 2) pertains to the source node s . It guarantees that the journey starts with defined origin. The constraint (Eq.3) pertains to the destination node t , ensuring that the route concludes at the specified destination. Constraint (Eq.4) encompasses all intermediary nodes k to illustrate that the entering flow is equivalent to the exiting flow. Constraint (Eq.5) represents a binary choice variable. x_{ij} equals 1 if the edge from i to j is included in the shortest path; otherwise, it equals 0.

Objective function

$$\text{Min } f_1 = \sum_{(i,j) \in E} d_{ij} x_{ij} \quad (1)$$

Subject to

$$\sum_{j:(s,j) \in E} x_{sj} - \sum_{i:(i,s) \in E} x_{is} = 1 \quad (2)$$

$$\sum_{j:(t,j) \in E} x_{tj} - \sum_{i:(i,t) \in E} x_{it} = -1 \quad (3)$$

$$\sum_{j:(k,j) \in E} x_{kj} - \sum_{i:(i,k) \in E} x_{ik} = 0, \quad \forall k \in V \setminus \{s, t\} \quad (4)$$

$$x_{ij} \in \{0,1\}, \quad \forall (i,j) \in E \quad (5)$$

C. Model 2 Route Optimization Prioritizes the Maximum Visitor Satisfaction Ratings

This model aims to provide travel routes that yield the greatest visitor satisfaction ratings. The objective function of this model is to maximize average visitor satisfaction (Eq. 6). The restrictions (2)-(5) are identical to those in the first model.

Objective function

$$Max f_2 = \sum_{(i,j) \in E} \frac{r_{ij}x_{ij}}{N} \quad (6)$$

Subject to
(2)-(5)

IV. CASE STUDY AND RESULTS

The developed models have been applied in a case study focusing on route planning to enhance the tourist industry throughout five provinces in the lower northeastern part of Thailand: Nakhon Ratchasima, Buriram, Surin, Si Sa Ket, and Ubon Ratchathani. These regions provide a compelling blend of cultural heritage, breathtaking landscapes, and traditional practices, making them an essential and vibrant part of the country. This study compiles information on travel destinations along with tourist satisfaction ratings and reviews from Wongnai.com (Wongnai, 2024), a prominent online platform and mobile application in Thailand that offers a directory for exploring local businesses related to travel, food, lifestyle, and wellness. Table 1 displays the lists of travel destinations, categories of attractions, and visitor satisfaction ratings. The location is illustrated via a map, and the transportation network of potential routes with distance and satisfaction ratings is depicted in Figs. 1 and 2 respectively.

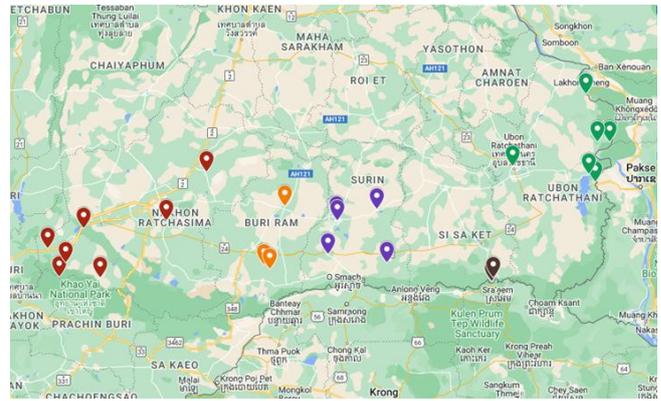


Fig. 1. Travel sites scattered in five provinces.

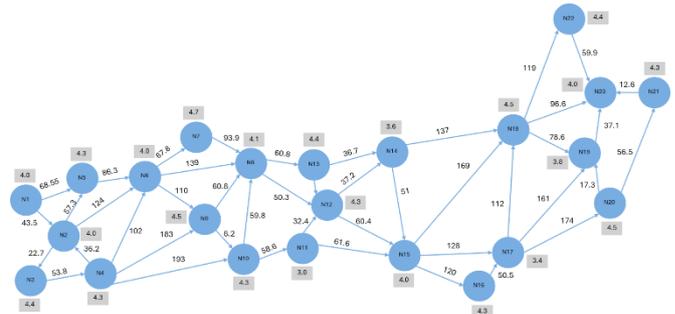


Fig. 2. Transportation network of possible routes.

Model 1, designed to minimize the total distance to selected locations, demonstrates through numerical experiments utilizing simplex algorithms that eight travel attractions are reachable. The proposed itinerary encompasses N1 - N5 - N6 - N8 - N12 - N14 - N18 - N23, commencing from Pak Chong district, Nakhon Ratchasima, the entry point to the northeastern region, and proceeding to Buriram, Surin, Si Sa Ket, ending at the northeasternmost point at Khong Chiam district, Ubon Ratchathani, covering a total distance of 614.9 kilometers (Table 2). This optimum path allows travelers to see a picturesque viewpoint, a pottery town, a historical landmark, and a temple.

Model 2 identifies nine trip destinations utilizing GRG algorithms in a numerical experiment, based on current online traveler satisfaction ratings. The organized itinerary starts in Nakhon Ratchasima, proceeds via Buriram and Surin, and finishes in Ubon Ratchathani, yielding an average satisfaction score of 4.06. The route includes N1 - N2 - N3 - N4 - N10 - N11 - N15 - N18 - N23. The ideal path provides access to a park and natural area, a pottery town, a historical site, and a temple (Table 2).

Table 1. The potential tourism spots and satisfaction ratings

Node	Name	City*	Type	Rating
1	Pak Chong District	1	Origin	4.00
2	Bhan Nam Pood Spring	1	Park/ Nature	4.00
3	Khao Yai National Park	1	Park/ Nature	4.40
4	Wang Nam Khiao	1	Village	4.30
5	Khao Yay Thieng	1	Scenic Point	4.30
6	Dan Kwian	1	Village	4.00
7	Phimai Historical Park	1	Historical Site	4.70
8	Chang Arena	2	Sport	4.10
9	Phanomrung Historical Park	2	Historical Site	4.50
10	Muang Tam Castle	2	Historical Site	4.30
11	Ban Pluang Castle	3	Historical Site	3.00
12	Surin City Pillar	3	Historical Site	4.30
13	Burapharam Temple	3	Temple	4.40
14	Sikhoraphum Castle	3	Historical Site	3.60
15	Phumphon Castle	3	Historical Site	4.00
16	Pha Mo E Dang Hill	4	Park/ Nature	4.30
17	Khao Phra Wihan	4	Park/Nature	3.40
18	Nong Bua Temple	5	Temple	4.50
19	Sirindhorn Dam	5	Scenic Point	3.80
20	Sirindhorn Wararam Phu Prao	5	Temple	4.50
21	Pha Taem National Park	5	Park/ Nature	4.30
22	Sam Phan Bok Grand Canyon	5	Park/Nature	4.40
23	Khong Chiam District	5	Destination	4.00

Remark *

- 1. Nakhon Ratchasima
- 2. Buriram
- 3. Surin
- 4. Si Sa Ket
- 5. Ubon Ratchathani

Table 2. Optimal tourism path for a case studies locations

Criteria	Optimal path	Total
Min. total distance	N1-N5-N6-N8-N12-N14-N18-N23	614.9 km
Max. average rating	N1-N2-N3-N4-N10-N11-N15-N18-N23	4.06 points

The linkages of each trip location produced by Model 1 and Model 2 are illustrated in Figs. 3 and 4 respectively.

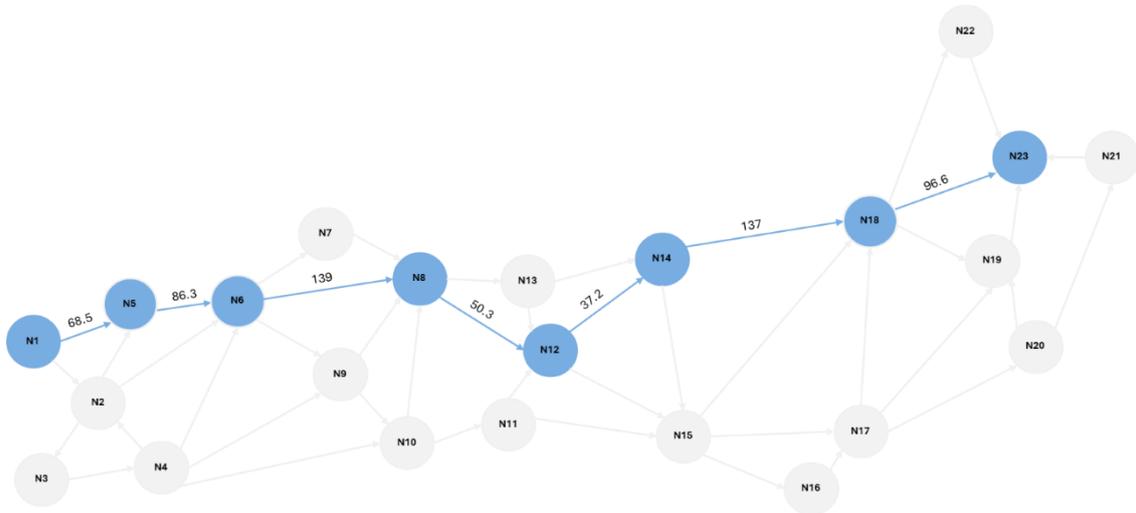


Fig. 3. Optimal tourism route prioritizing minimum of total distance.

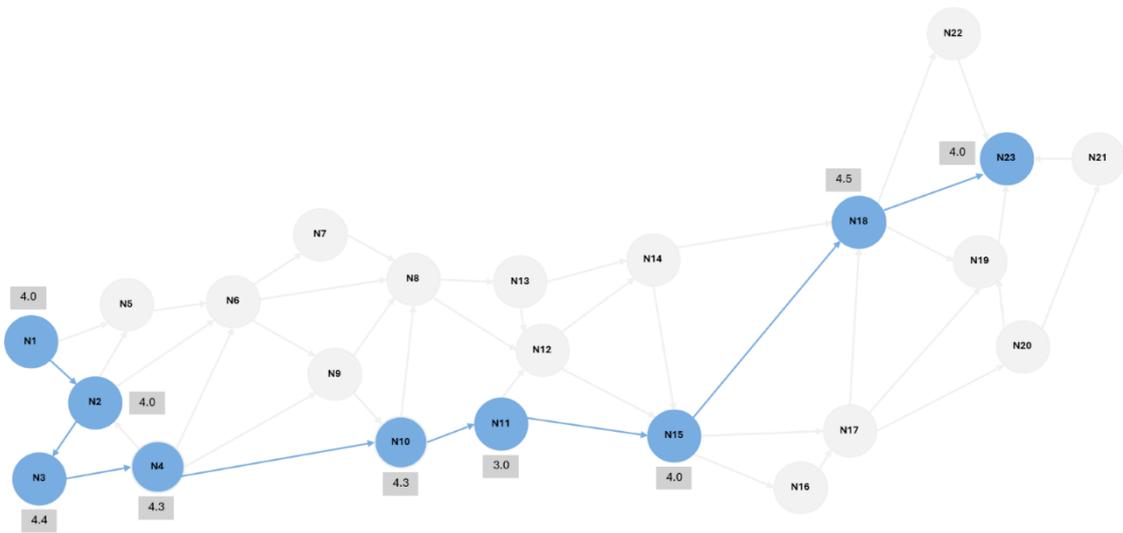


Fig. 4. Optimal tourism route prioritizing maximum visitors' satisfaction rating.

V. CONCLUSION AND DISCUSSION

This article demonstrates the application of the shortest path technique to enhance the transportation network, hence increasing the efficiency of the tourist sector in case study areas. The numerical experiment findings produced by this study will serve as a valuable guideline for the tourist authority of Thailand in formulating strategies or initiating campaigns to enhance the tourist sector in the lower northeastern region of Thailand. Moreover, prioritizing travelers' satisfaction rankings in trip planning, the ideal route not only highlights areas to promote to tourists but also guides tourism authorities in enhancing underrepresented travel destinations to attract more tourist visitation. Setting priorities for distance in trip planning, the findings produced may aid travelers in organizing their journeys more efficiently, especially for reaching locations that need a private vehicle owing to insufficient public transportation. Comprehensive information pertaining to routing and location would be appealing to both Thai tourists and international visitors.

However, the limitation of this paper relates to the rating data of tourist pleasure. The satisfaction scores are derived from online information, with each attraction having a distinct number of voters. Certain attractions receive numerous comments, but others do not, resulting in possible

errors in the scores utilized in the model. The vote ratings reflect the general satisfaction with the attraction, without detailing the specific issues under evaluation.

The authors plan on using the voting scores to develop a mathematical model in future research, examining certain satisfaction domains such as food, accommodation, and traffic, which will facilitate the optimization of tourism logistics network management.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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