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Two-Stage Entropy-Topsis Model For Hotel And Ecotourism Destination Selection in Bitung, North Sulawesi, Indonesia

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Abstract: This study develops a Two-Stage Entropy-TOPSIS model for hotel and ecotourism destination selection in Bitung, North Sulawesi, Indonesia. The model reflects a realistic tourist decision process, where tourists first select a hotel from the airport and then choose ecotourism destinations from the selected hotel as the starting point. Data were collected from Google Maps, including rating, number of reviews, distance, travel time, hotel facility score, and ecotourism suitability score. In the first stage, eight hotel alternatives were evaluated based on Google Maps rating, number of reviews, distance from Sam Ratulangi Airport, travel time from the airport, and facility score. The Entropy method was used to determine objective criteria weights, while TOPSIS was applied to rank alternatives. The results showed that favehotel Bitung ranked first with a preference value of 0.9999 and was selected as the origin point for the second stage. In the second stage, ecotourism destinations were evaluated using the selected hotel as the starting point. The main calculation included destinations with complete road-based accessibility data. The results showed that Kebun Binatang Tandurusa ranked first with a preference value of 0.9989, followed by Batuangus Beach, Pantai Tanjung Merah, and Pantai Lilang. The primary contributions is to demonstrates the transformation of unstructured Google Maps data into two-stage Decision Support System. These findings indicate that the proposed model can provide structured, sequential, and data-driven recommendations for tourism decision-making based on Google Maps data.
Keywords: Decision Support System; Ecotourism; Entropy; Hotel selection; TOPSIS

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1. INTRODUCING

Ecotourism and coastal tourism have become increasingly important in destination development because they connect recreational activities with environmental conservation, local economic benefits, nature-based experiences, and sustainable tourism practices. Recent ecotourism studies show that this field continues to expand as a research area and is closely related to sustainability, environmental protection, destination planning, and responsible tourism management [1], [2]. In coastal regions such as Bitung, North Sulawesi, Indonesia, ecotourism and coastal tourism are relevant because tourism activities are strongly connected to beaches, marine environments, conservation areas, wildlife attractions, and nature-based destinations.

Digital technology has transformed the way tourists search for, compare, and select travel-related services. Tourists increasingly rely on online information such as ratings, reviews, distance, travel time, and location data before making travel decisions. Online travel reviews influence tourists' perceived destination image and can shape how tourists evaluate destination attractiveness [3]. Google Reviews has also been recognized as a useful source for tourism research because it provides large-scale user-generated data that can help researchers understand visitor perceptions, although it also has limitations that must be considered carefully [4].

Online reviews have also been widely used to analyze tourist experience, satisfaction, and service improvement. Nawawi et al. used online reviews to explore tourist experiences through aspect-based sentiment analysis [5], while Riswanto et al. analyzed Google Travel reviews to identify satisfaction factors in cultural tourism destinations [6]. Chu et al. demonstrated that text mining and sentiment analysis can be applied to travel review data to understand tourists' perceptions of travel guidance platforms [7]. These studies indicate that online review data are not only useful for describing tourist opinions but can also support data-driven tourism decision-making.

The quality of online tourism information also affects tourists' decision-making processes. Wang and Yan found that social media tourism information quality influences destination travel intention through self-congruity and trust [8]. Wang et al. showed that online tourism information quality contributes to the formation of conative destination image through cognitive and affective resonance [9]. Zhou et al. further emphasized that online word of mouth can influence tourists' travel intentions [10]. These findings show that digital information, including online reviews and user-generated content, plays a significant role in tourism decision-making.

In tourism planning, the travel decision process often involves more than one decision. Tourists usually do not only select a destination; they also select accommodation as a temporary base before visiting tourism attractions. Therefore, hotel selection and destination selection are connected decisions. Recent hotel recommendation studies have shown that online reviews, rating data, attribute importance, and customer preferences can be used to develop more adaptive and structured hotel selection models [11], [12], [13], [14]. This indicates that hotel selection should be integrated with destination selection, especially when accessibility from the selected hotel affects the feasibility of visiting tourism destinations.

Hotel and destination selection are multi-criteria decision-making problems because several criteria must be evaluated simultaneously. In hotel selection, tourists may consider Google Maps rating, number of reviews, distance from the airport, travel time from the airport, and facility score. In destination selection, tourists may consider rating, number of reviews, distance from the selected hotel, travel time from the selected hotel, and ecotourism suitability. Because these criteria have different scales and directions, a structured Decision Support System is needed to transform the data into an objective recommendation model.

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The Entropy method and the Technique for Order Preference by Similarity to Ideal Solution, or TOPSIS, are suitable methods for solving multi-criteria decision-making problems. The Entropy method determines objective criteria weights based on data variation, reducing subjectivity in the weighting process [15]. TOPSIS ranks alternatives based on their closeness to the positive ideal solution and their distance from the negative ideal solution. A recent comprehensive review also confirms that TOPSIS remains widely used because of its rational concept, computational simplicity, and applicability across various decision-making problems [16].

In tourism studies, TOPSIS and Entropy-TOPSIS have been applied in several contexts, including ecotourism capability assessment, sustainable development evaluation, and tourism economic resilience analysis. Zhu et al. used SWOT and TOPSIS to evaluate ecotourism capabilities[17], while Zhao et al. applied Entropy and TOPSIS to evaluate sustainable development in island areas [18]. Zhao et al. also used an entropy-weighted evaluation approach in tourism economic resilience analysis[19]. These studies show that Entropy-TOPSIS is relevant for tourism-related decision problems involving multiple alternatives and criteria.

Despite the growing literature on online reviews, hotel recommendation, and tourism decision-making, several research gaps remain. First, many hotel recommendation studies focus on hotel selection as a single decision and do not connect the selected hotel with subsequent destination selection. Second, many destination selection studies use a fixed origin such as a city center or airport, whereas real tourist movement often starts from the selected accommodation. Third, studies using Google Maps data often focus on review analysis or tourist satisfaction rather than transforming rating, review volume, distance, and travel time into a two-stage decision support model. Fourth, limited studies have developed a sequential model that first selects a hotel from the airport and then uses the selected hotel as the origin for ecotourism destination ranking.

The novelty of this study lies in the development of a Two-Stage Entropy-TOPSIS model for hotel and ecotourism destination selection in Bitung, North Sulawesi, Indonesia. In the first stage, hotel alternatives are evaluated using Google Maps rating, number of reviews, distance from Sam Ratulangi Airport, travel time from the airport, and facility score. The best-ranked hotel is then used as the starting point for the second stage. In the second stage, ecotourism destination alternatives are evaluated based on rating, number of reviews, distance from the selected hotel, travel time from the selected hotel, and ecotourism suitability score. This approach creates a sequential recommendation model that better reflects actual tourist travel behavior.

This study contributes to Information Systems and tourism management. From the Information Systems perspective, it demonstrates how Google Maps data can be transformed into a structured two-stage Decision Support System using Entropy-TOPSIS. From the tourism management perspective, it provides insight into the importance of digital reputation, accessibility, accommodation selection, and ecotourism suitability in supporting travel decisions. The model can help tourists make more structured travel choices and assist hotel and destination managers in improving digital visibility, review engagement, accessibility information, and destination competitiveness.

Therefore, this study aims to develop a Two-Stage Entropy-TOPSIS Model for Hotel and Ecotourism Destination Selection in Bitung, North Sulawesi, Indonesia. Specifically, the study aims to determine the best hotel from Sam Ratulangi Airport, use the selected hotel as the starting point for ecotourism destination evaluation, calculate objective criteria weights using Entropy, rank alternatives using TOPSIS, and provide data-driven recommendations based on Google Maps information.

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2. METHOD

Research Design

This study used a descriptive quantitative approach with a two-stage Decision Support System (DSS) model. The quantitative approach was applied because the data consisted of numerical values, including Google Maps rating, number of reviews, distance, travel time, hotel facility score, and ecotourism suitability score. The descriptive approach was used to explain the data collection process, criteria determination, data transformation, criteria weighting, and alternative ranking.

The study applied a Two-Stage Entropy-TOPSIS model. In the first stage, the model was used to select the best hotel in Bitung based on its accessibility from Sam Ratulangi Airport and its digital reputation on Google Maps. In the second stage, the selected hotel from the first stage was used as the starting point for selecting ecotourism destinations in Bitung. This two-stage structure reflects a realistic tourist travel pattern, in which tourists first arrive at the airport, choose a hotel, and then visit tourism destinations from the hotel.

The Entropy method was used to determine objective criteria weights based on data variation. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was used to rank alternatives based on their closeness to the positive ideal solution and their distance from the negative ideal solution.

Research Framework

The research framework consisted of two main stages: hotel selection and ecotourism destination selection.

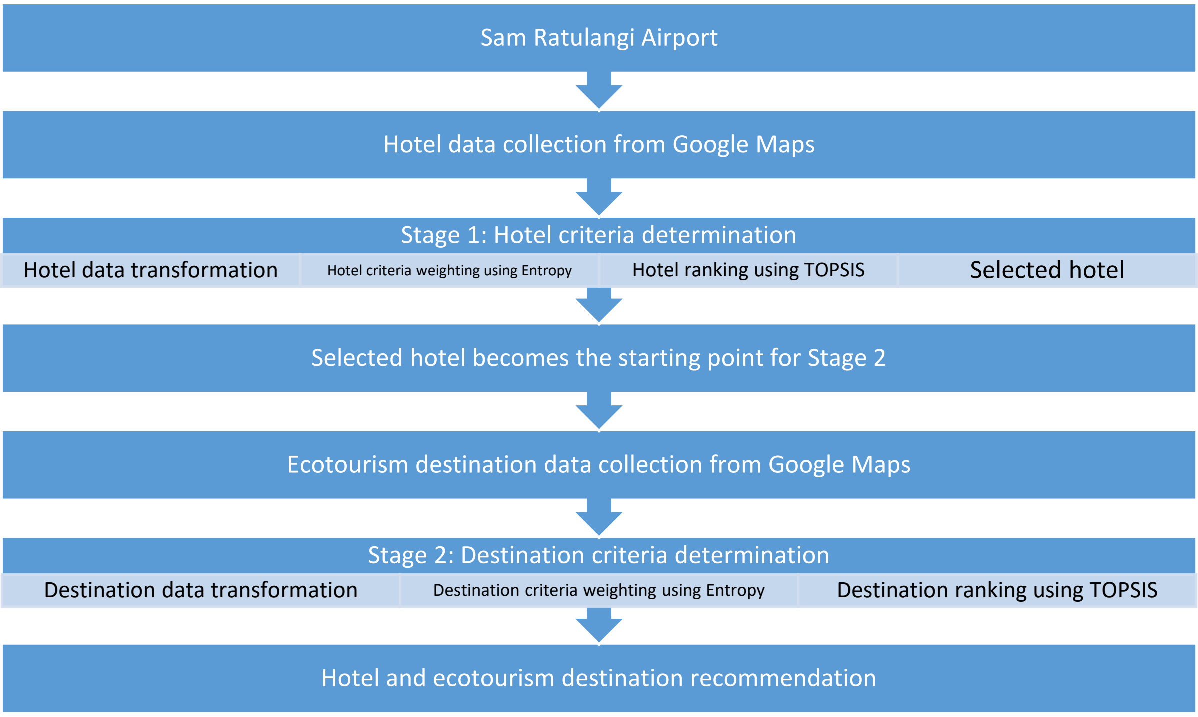

Figure 1. Two-stage Entropy-TOPSIS research framework

Figure 1 shows the two-stage research process used in this study. The first stage evaluates hotel alternatives using Entropy-TOPSIS and produces the best hotel as the output. The selected hotel then becomes the origin point in the second stage. The second

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stage evaluates ecotourism destinations based on rating, number of reviews, accessibility from the selected hotel, and ecotourism suitability. This framework allows the recommendation process to follow a more realistic tourism decision flow.

Data Source and Data Collection

The data were collected from Google Maps. The data used in the first stage included hotel rating, number of reviews, distance from Sam Ratulangi Airport, travel time from the airport, facility score, coordinates, and Google Maps links. The distance and travel time were measured using car as the transportation mode and the fastest route available on Google Maps.

In the second stage, the selected hotel from the first stage was used as the starting point to measure distance and travel time to ecotourism destinations. Some destinations required boat access, making their distance and travel time incomparable with destinations accessible by car. Therefore, destinations with non-numeric distance or travel time were recorded as part of the candidate list but were not included in the main TOPSIS calculation unless comparable total travel data were available.

Table 1. Data collection setting

Component	Description
Stage 1 starting point	Sam Ratulangi Airport
Stage 1 alternatives	Hotel alternatives in Bitung
Stage 2 starting point	Best hotel selected in Stage 1
Stage 2 alternatives	Ecotourism destination alternatives in Bitung
Data source	Google Maps
Transportation mode	Car
Route selection	Fastest route on Google Maps
Main method	Entropy-TOPSIS

Table 1 presents the general setting for data collection. In the first stage, all hotel distances and travel times were measured from Sam Ratulangi Airport. In the second stage, all destination distances and travel times were measured from the selected hotel. The use of the same transportation mode and route selection rule was intended to ensure consistency across alternatives.

Stage 1: Hotel Alternatives

The first stage evaluated eight hotel alternatives in Bitung. These hotels were selected because they had available Google Maps data, including rating, number of reviews, distance, travel time, facility score, and coordinates.

Table 2. Hotel alternatives for Stage 1

Code	Hotel Name	Rating	Number of Reviews	Distance from Airport (km)	Travel Time from Airport (minutes)	Facility Score	Coordinates
H01	favehotel Bitung	4.8	2243	44.3	77	4	1.4446597, 125.1785187
H02	Bahari Family Hotel	4.4	108	46.3	82	3.9	1.4484596, 125.1966039

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Code	Hotel Name	Rating	Number of Reviews	Distance from Airport (km)	Travel Time from Airport (minutes)	Facility Score	Coordinates
H03	Summer Hotel Bitung	4	538	45.6	80	3.9	1.4458177, 125.1881459
H04	Tangkoko Sanctuary Villa	4.9	119	49.6	103	3.2	1.5615523, 125.1508839
H05	Renny's Tangkoko Safety Stop	4.8	38	48.1	97	3	1.5690372, 125.1543925
H06	Tangkoko Lodge	4.4	13	61.7	85	3.1	1.5670118, 125.1525784
H07	Cocotinos Lembeh A Boutique Dive Lodge	4.4	185	54.2	96	3.2	1.4764935, 125.1910211
H08	Kaya Kirana Lembeh	5	38	50.2	87	3.4	1.4366005, 125.1774775

Table 2 shows the hotel alternatives evaluated in the first stage. Each hotel has different characteristics in terms of digital reputation, accessibility from the airport, and facility score. These data were used as the decision matrix for selecting the best hotel, which then became the starting point for the second stage.

Stage 1 Criteria

The hotel selection stage used five criteria: Google Maps rating, number of reviews, distance from the airport, travel time from the airport, and facility score.

Table 3. Stage 1 hotel selection criteria

Code	Criterion	Criterion Type	Description
H-C1	Google Maps rating	Benefit	Higher rating indicates better hotel evaluation
H-C2	Number of reviews	Benefit	Higher number of reviews indicates stronger digital reputation
H-C3	Distance from airport	Cost	Shorter distance indicates better accessibility
H-C4	Travel time from airport	Cost	Shorter travel time indicates better accessibility
H-C5	Facility score	Benefit	Higher score indicates better hotel facilities

Table 3 explains the criteria used to evaluate hotel alternatives. Rating, number of reviews, and facility score were classified as benefit criteria because higher values indicate better alternatives. Distance and travel time were classified as cost criteria because lower values are preferred.

Hotel Facility Score

The facility score was used to quantify the completeness of hotel facilities based on online information. The score ranged from 1 to 5.

Table 4. Hotel facility score scale

Score	Category	Description
5	Very complete	Main and supporting facilities are very complete

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Score	Category	Description
4	Complete	Most main hotel facilities are available
3	Moderate	Basic facilities are available
2	Limited	Only a few facilities are visible
1	Very limited	Facility information is very limited or unavailable

Table 4 presents the scoring scale for hotel facilities. This score was used because facility information is not always available as numerical data on Google Maps. Therefore, the facility score converted qualitative online facility information into a numerical value that could be processed in the Entropy-TOPSIS model.

Stage 2: Ecotourism Destination Alternatives

The second stage evaluated ecotourism destination alternatives in Bitung. The selected hotel from Stage 1 was used as the starting point. Eight destinations were initially identified as candidate alternatives. However, destinations requiring boat access were not included in the main TOPSIS calculation unless comparable distance and travel time values were available.

Table 5. Ecotourism destination candidates for Stage 2

Code	Destination	Category	Rating	Number of Reviews	Distance from Selected Hotel (km)	Travel Time from Selected Hotel (minutes)	Ecotourism Suitability Score	Coordinates
D01	Kebun Binatang Tandurusa	Ecotourism / wildlife	3.9	539	5.3	12	3	1.4556463, 125.2007243
D02	Lembeh Strait	Marine tourism / diving	5	14	Need boat	-	1	1.4525882, 125.204455
D03	Batuangus Beach	Coastal / nature tourism	4.6	482	12.4	29	3	1.5056145, 125.2243465
D04	Pantai Serena	Coastal tourism	4.1	105	Need boat	-	3	1.4593874, 125.215577
D05	Ecotourism Mangrove Lirang	Mangrove ecotourism	4.2	23	Need boat	-	2	1.5437941, 125.2897509
D06	Pantai Tanjung Merah	Coastal tourism	4	193	11.8	22	1	1.4045249, 125.1154242
D07	Pantai Kahona	Coastal tourism	4.2	144	Need boat	-	3	1.3984673, 125.183967
D08	Pantai Lilang	Ecotourism / coastal	4.4	94	26	47	2	1.3682827, 125.0314678

Table 5 presents the ecotourism destination candidates identified for the second stage. Four destinations had complete road-based distance and travel time data, while four destinations required boat access. Since the study used car-based travel time and the fastest Google Maps route as the main measurement standard, boat-access destinations were excluded from the main quantitative ranking to maintain comparability.

Main Stage 2 Alternatives Used in TOPSIS Calculation

The main TOPSIS calculation in Stage 2 used destinations with complete numerical data for distance and travel time.

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Table 6. Ecotourism destinations included in the main Stage 2 calculation

Code	Destination	Category	Rating	Number of Reviews	Distance from Selected Hotel (km)	Travel Time from Selected Hotel (minutes)	Ecotourism Suitability Score
D01	Kebun Binatang Tandurusa	Ecotourism / wildlife	3.9	539	5.3	12	3
D03	Batuangus Beach	Coastal / nature tourism	4.6	482	12.4	29	3
D06	Pantai Tanjung Merah	Coastal tourism	4	193	11.8	22	1
D08	Pantai Lilang	Ecotourism / coastal	4.4	94	26	47	2

Table 6 shows the destinations included in the main Stage 2 Entropy-TOPSIS calculation. These alternatives were selected because they had complete numerical values for distance and travel time from the selected hotel. Excluding destinations that required boat access helped maintain consistency in the accessibility criteria.

Stage 2 Criteria

The destination selection stage used five criteria: Google Maps rating, number of reviews, distance from the selected hotel, travel time from the selected hotel, and ecotourism suitability score.

Table 7. Stage 2 ecotourism destination selection criteria

Code	Criterion	Criterion Type	Description
D-C1	Google Maps rating	Benefit	Higher rating indicates better destination evaluation
D-C2	Number of reviews	Benefit	Higher number of reviews indicates stronger digital reputation
D-C3	Distance from selected hotel	Cost	Shorter distance indicates better accessibility
D-C4	Travel time from selected hotel	Cost	Shorter travel time indicates better accessibility
D-C5	Ecotourism suitability score	Benefit	Higher score indicates stronger relevance to ecotourism

Table 7 presents the criteria used for the second-stage destination evaluation. Rating, number of reviews, and ecotourism suitability score were classified as benefit criteria. Distance and travel time were classified as cost criteria because shorter travel distance and time are more favorable for tourists.

Ecotourism Suitability Score

The ecotourism suitability score was used to assess how strongly each destination was related to ecotourism, coastal tourism, marine tourism, conservation, wildlife, or nature-based tourism.

Table 8. Ecotourism suitability score scale

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Score	Category	Description
5	Very high suitability	Main destination based on conservation, wildlife, diving, mangrove, natural beach, or ecotourism
4	High suitability	Destination has strong natural, coastal, marine, or conservation elements
3	Moderate suitability	Destination has clear ecotourism, wildlife, or coastal tourism elements
2	Low suitability	Destination has some ecotourism or coastal elements but is not a primary ecotourism object
1	Very low suitability	Destination has weak relevance to ecotourism or coastal tourism

Table 8 explains the scoring scale used to measure ecotourism suitability. This score was required because destinations differ in their relevance to ecotourism. Destinations with stronger links to wildlife, conservation, marine tourism, mangroves, or natural coastal landscapes received higher scores.

Data Transformation

Before applying Entropy and TOPSIS, cost criteria were transformed into benefit criteria so that all criteria had the same evaluation direction. In this study, distance and travel time were cost criteria in both stages.

The cost-to-benefit transformation formula is:

$$x'_{ij} = \frac{\min(x_j)}{x_{ij}} \tag{1}$$

For benefit criteria, the original value was used directly:

$$x'_{ij} = x_{ij} \tag{2}$$

where:

x'_{ij} = transformed value of alternative i on criterion j

$\min(x_j)$ = minimum value of criterion j

x_{ij} = original value of alternative i on criterion j

Table 9. Criteria transformation treatment

Criterion Type	Transformation Formula	Interpretation
Benefit	$x'_{ij} = x_{ij}$	Higher value indicates better alternative
Cost	$x'_{ij} = \frac{\min(x_j)}{x_{ij}}$	Lower original value produces higher transformed value

Table 9 shows the data transformation procedure. Benefit criteria were used directly, while cost criteria were converted into benefit criteria. This transformation ensured that all criteria followed the same direction, where larger values indicated better alternatives.

Entropy Weighting Method

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The Entropy method was used to determine objective criteria weights. Objective weighting means that the weight of each criterion was calculated based on data variation rather than subjective judgments from respondents or experts.

The decision matrix is expressed as:

$$X = [x_{ij}]_{m\times n}$$

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{3}$$

The proportion value of each alternative for each criterion was calculated using:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{4}$$

The Entropy constant was calculated as:

$$k = \frac{1}{\ln(m)} \tag{5}$$

The Entropy value of each criterion was calculated using:

$$e_j = -k \sum_{i=1}^{m} p_{ij} \ln(p_{ij}) \tag{6}$$

If $p_{ij} = 0$, then:

$$p_{ij} \ln(p_{ij}) = 0 \tag{7}$$

The degree of diversification was calculated as:

$$d_j = 1 - e_j \tag{8}$$

The criterion weight was calculated as:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \tag{9}$$

where:
x_{ij}= value of alternative $i$on criterion j
p_{ij}= proportion value of alternative $i$on criterion j
e_j= Entropy value of criterion j
d_j= degree of diversification of criterion j
w_j= weight of criterion j
m= number of alternatives
n= number of criteria

TOPSIS Ranking Method

The TOPSIS method was used to rank hotel alternatives in Stage 1 and ecotourism destination alternatives in Stage 2. The best alternative in TOPSIS is the alternative closest to the positive ideal solution and farthest from the negative ideal solution.

The normalized decision matrix was calculated using:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{10}$$

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The weighted normalized matrix was calculated using:

$$v_{ij} = w_j \times r_{ij} \tag{11}$$

Because all criteria had been transformed into benefit criteria, the positive ideal solution and negative ideal solution were determined as follows:

$$A_j^+ = \max(v_{ij})$$
$$A_j^- = \min(v_{ij}) \tag{12}$$

The distance of each alternative from the positive ideal solution was calculated using:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - A_j^+)^2} \tag{13}$$

The distance of each alternative from the negative ideal solution was calculated using:

$$D_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - A_j^-)^2} \tag{14}$$

The preference value was calculated using:

$$V_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{15}$$

where:
r_{ij} = normalized value of alternative i on criterion j
v_{ij} = weighted normalized value of alternative i on criterion j
A_j^+ = positive ideal solution for criterion j
A_j^- = negative ideal solution for criterion j
D_i^+ = distance of alternative i from the positive ideal solution
D_i^- = distance of alternative i from the negative ideal solution
V_i = preference value of alternative i

The value of V_i ranges from 0 to 1. A higher V_i indicates a better alternative. The hotel with the highest preference value in Stage 1 was selected as the origin point for Stage 2.

Two-Stage Analysis Procedure

The analysis was conducted sequentially. Stage 1 evaluated hotel alternatives using Entropy-TOPSIS. The best hotel from Stage 1 was then used as the origin point in Stage 2. Stage 2 evaluated ecotourism destination alternatives using the same Entropy-TOPSIS procedure.

Table 10. Two-stage analysis procedure

Stage	**Input**	**Process**	**Output**
Stage 1	Hotel dataset	Entropy weighting and TOPSIS ranking	Selected hotel
Stage 2	Ecotourism destination dataset	Entropy weighting and TOPSIS ranking	Recommended ecotourism destination
Final result	Selected hotel and destination ranking	Interpretation	Travel decision recommendation

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Table 10 summarizes the two-stage analysis procedure. Stage 1 produces the best hotel alternative, while Stage 2 produces the best ecotourism destination alternative based on the selected hotel. This procedure allows the study to provide a more practical travel recommendation.

Data Analysis Tool

Data processing was conducted using Microsoft Excel. Excel was used to arrange the dataset, transform cost criteria into benefit criteria, calculate Entropy weights, normalize the TOPSIS matrix, determine positive and negative ideal solutions, calculate the distance of each alternative from the ideal solutions, and obtain the final preference values.

Microsoft Excel was selected because the Entropy-TOPSIS calculation can be performed transparently using formulas, allowing the analysis process to be verified and replicated.

Data Validity and Limitations

Data validity was maintained by using the same data source, namely Google Maps. Distance and travel time were measured using the same transportation mode, namely car, and the fastest route option on Google Maps. In Stage 1, all hotel alternatives were measured from Sam Ratulangi Airport. In Stage 2, all destination alternatives included in the main calculation were measured from the selected hotel.

This study has several limitations. First, Google Maps ratings and numbers of reviews may change over time as new user reviews are added. Second, distance and travel time may change due to traffic conditions, route changes, or Google Maps system updates. Third, hotel facility scores and ecotourism suitability scores involved researcher judgment based on online information. Fourth, several ecotourism destinations required boat access, so they were excluded from the main Stage 2 TOPSIS calculation because their distance and travel time were not directly comparable with car-accessible destinations.

3. RESULT AND DISCUSSIONS

Stage 1: Hotel Selection Results

The first stage was conducted to determine the best hotel in Bitung. The evaluation used five criteria: Google Maps rating, number of reviews, distance from Sam Ratulangi Airport, travel time from the airport, and hotel facility score. In this stage, rating, number of reviews, and facility score were treated as benefit criteria, while distance and travel time were treated as cost criteria.

Before applying Entropy and TOPSIS, the cost criteria were transformed into benefit criteria. The minimum distance from the airport was 44.3 km, obtained by favehotel Bitung, while the minimum travel time was 77 minutes, also obtained by favehotel Bitung. The transformed decision matrix is shown in Table 11.

Table 11. Transformed decision matrix for hotel selection

Code	Hotel Name	C1 Rating	C2 Reviews	C3 Distance	C4 Travel Time	C5 Facility
H01	favehotel Bitung	4.8	2243	1	1	4
H02	Bahari Family Hotel	4.4	108	0.9568	0.939	3.9
H03	Summer Hotel Bitung	4	538	0.9715	0.9625	3.9
H04	Tangkoko Sanctuary Villa	4.9	119	0.8931	0.7476	3.2

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H05	Renny's Tangkoko Safety Stop	4.8	38	0.921	0.7938	3
H06	Tangkoko Lodge	4.4	13	0.718	0.9059	3.1
H07	Cocotinos Lembeh A Boutique Dive Lodge	4.4	185	0.8173	0.8021	3.2
H08	Kaya Kirana Lembeh	5	38	0.8825	0.8851	3.4

Table 11 shows that favehotel Bitung obtained the highest transformed values for distance and travel time because it had the shortest distance and fastest travel time from Sam Ratulangi Airport. Meanwhile, Tangkoko Lodge obtained the lowest transformed distance value because it had the farthest distance from the airport. This transformed matrix was used as the input for the Entropy weighting and TOPSIS ranking processes.

Stage 1 Entropy Weighting Results

The Entropy method was used to calculate objective criteria weights based on data variation. The results of the Entropy weighting for hotel selection are presented in Table 12.

Table 12. Entropy weighting results for hotel selection

Code	Criterion	Entropy Value	Degree of Diversification	Weight
H-C1	Google Maps rating	0.9988	0.0012	0.0024
H-C2	Number of reviews	0.5177	0.4823	0.9826
H-C3	Distance from airport	0.9977	0.0023	0.0046
H-C4	Travel time from airport	0.9978	0.0022	0.0045
H-C5	Facility score	0.9971	0.0029	0.0059

Table 12 indicates that the number of reviews had the highest weight, with a value of 0.9826. This result occurred because the number of reviews varied substantially among hotels. favehotel Bitung had 2,243 reviews, while several other hotels had fewer than 200 reviews. Therefore, the number of reviews became the strongest differentiating criterion in the hotel selection model. In contrast, Google Maps rating had the lowest weight because the rating values among hotels were relatively close.

Stage 1 TOPSIS Ideal Solutions

After the criteria weights were obtained, the TOPSIS method was applied to rank the hotel alternatives. The positive ideal solution represents the best value for each criterion, while the negative ideal solution represents the lowest value for each criterion after weighted normalization.

Table 13. Positive and negative ideal solutions for hotel selection

Criterion	Positive Ideal Solution	Negative Ideal Solution
H-C1 Rating	0.0009	0.0007
H-C2 Number of reviews	0.9499	0.0055
H-C3 Distance	0.0018	0.0013
H-C4 Travel time	0.0018	0.0013
H-C5 Facility	0.0024	0.0018

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Table 13 shows that the largest difference between the positive and negative ideal solutions appeared in the number of reviews criterion. This result confirms that digital reputation, represented by review volume, strongly influenced the hotel ranking in the first stage.

Stage 1 Hotel Ranking Results

The TOPSIS preference value was calculated based on the distance of each alternative from the positive and negative ideal solutions. The hotel ranking results are presented in Table 14.

Rank	Code	Hotel Name	D_i^+	D_i^-	Preference Value
1	H01	favehotel Bitung	0	0.9444	0.9999
2	H03	Summer Hotel Bitung	0.7221	0.2223	0.2354
3	H07	Cocotinos Lembeh A Boutique Dive Lodge	0.8715	0.0728	0.0771
4	H04	Tangkoko Sanctuary Villa	0.8995	0.0449	0.0475
5	H02	Bahari Family Hotel	0.9042	0.0402	0.0426
6	H08	Kaya Kirana Lembeh	0.9338	0.0106	0.0112
7	H05	Renny's Tangkoko Safety Stop	0.9338	0.0106	0.0112
8	H06	Tangkoko Lodge	0.9444	0.0003	0.0003

Table 14. TOPSIS ranking results for hotel selection

Table 14 shows that favehotel Bitung ranked first with a preference value of 0.9999. This hotel was selected as the best hotel in Stage 1. Therefore, favehotel Bitung became the starting point for Stage 2 destination selection. The result was strongly influenced by the high number of reviews, short distance from the airport, fast travel time, and relatively high facility score.

Example of Stage 1 Calculation

For the distance criterion, the minimum distance was 44.3 km. The distance from Sam Ratulangi Airport to Bahari Family Hotel was 46.3 km. Therefore, the transformed distance value was calculated as:

$$x'_{H02,H-C3} = \frac{44.3}{46.3}$$
$$x'_{H02,H-C3} = 0.9568$$

For the travel time criterion, the minimum travel time was 77 minutes. The travel time from the airport to Summer Hotel Bitung was 80 minutes. Therefore, the transformed travel time value was:

$$x'_{H03,H-C4} = \frac{77}{80}$$
$$x'_{H03,H-C4} = 0.9625$$

The preference value for favehotel Bitung was calculated from the TOPSIS distance values:

$$V_{H01} = \frac{D^-_{H01}}{D^+_{H01} + D^-_{H01}}$$

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$$V_{H01} = \frac{0.9444}{0.0000 + 0.9444}$$
$$V_{H01} = 0.9999$$

This value indicates that favehotel Bitung was located very close to the positive ideal solution and far from the negative ideal solution.

Stage 2: Ecotourism Destination Selection Results

The second stage was conducted to rank ecotourism destinations in Bitung using favehotel Bitung as the starting point. Initially, eight destinations were identified. However, four destinations required boat access and did not have comparable road-based distance and travel time data. Therefore, the main TOPSIS calculation used only destinations with complete numerical distance and travel time data.

The destinations included in the main calculation were Kebun Binatang Tandurusa, Batuangus Beach, Pantai Tanjung Merah, and Pantai Lilang. The transformed decision matrix is shown in Table 15.

Table 15. Transformed decision matrix for ecotourism destination selection

Code	Destination	C1 Rating	C2 Reviews	C3 Distance	C4 Travel Time	C5 Suitability
D01	Kebun Binatang Tandurusa	3.9	539	1	1	3
D03	Batuangus Beach	4.6	482	0.4274	0.4138	3
D06	Pantai Tanjung Merah	4	193	0.4492	0.5455	1
D08	Pantai Lilang	4.4	94	0.2038	0.2553	2

Table 15 shows that Kebun Binatang Tandurusa obtained the highest transformed distance and travel time values because it was the nearest destination from favehotel Bitung and had the shortest travel time. Batuangus Beach had the highest rating among the destinations included in the calculation, while Kebun Binatang Tandurusa had the highest number of reviews.

Stage 2 Entropy Weighting Results

The Entropy method was again used to determine objective criteria weights for destination selection. The results are presented in Table 16.

Table 16. Entropy weighting results for ecotourism destination selection

Code	**Criterion**	**Entropy Value**	**Degree of Diversification**	**Weight**
D-C1	Google Maps rating	0.9983	0.0017	0.0043
D-C2	Number of reviews	0.8691	0.1309	0.3428
D-C3	Distance from selected hotel	0.8915	0.1085	0.2842
D-C4	Travel time from selected hotel	0.9137	0.0863	0.226
D-C5	Ecotourism suitability score	0.9455	0.0545	0.1426

Table 16 shows that the highest weight in Stage 2 was the number of reviews, with a weight of 0.3428. The second-highest weight was distance from the selected hotel, with a weight of 0.2842, followed by travel time with 0.2260, ecotourism suitability score with 0.1426, and rating with 0.0043. Unlike Stage 1, the number of reviews did not completely

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dominate the weighting structure in Stage 2 because the variation among destination reviews was less extreme than that among hotel reviews.

Stage 2 TOPSIS Ideal Solutions

The positive and negative ideal solutions for the destination selection stage are presented in Table 17.

Table 17. Positive and negative ideal solutions for ecotourism destination selection

Criterion	Positive Ideal Solution	Negative Ideal Solution
D-C1 Rating	0.0023	0.002
D-C2 Number of reviews	0.245	0.0427
D-C3 Distance	0.238	0.0485
D-C4 Travel time	0.1825	0.0466
D-C5 Suitability	0.0892	0.0297

Table 17 shows the best and lowest weighted normalized values for each destination criterion. The positive ideal solution represents the most desirable condition, namely higher rating, more reviews, shorter distance, shorter travel time, and higher ecotourism suitability. These ideal solution values were used to calculate the final preference values for each destination.

Stage 2 Destination Ranking Results

The TOPSIS ranking results for the ecotourism destinations are shown in Table 18.

Table 18. TOPSIS ranking results for ecotourism destination selection

Rank	Code	Destination	D_i^+	D_i^-	Preference Value
1	D01	Kebun Binatang Tandurusa	0.0004	0.3144	0.9989
2	D03	Batuangus Beach	0.1752	0.1957	0.5277
3	D06	Pantai Tanjung Merah	0.2288	0.0908	0.284
4	D08	Pantai Lilang	0.3101	0.0297	0.0875

Table 18 shows that Kebun Binatang Tandurusa ranked first with a preference value of 0.9989. The destination achieved the best result because it had the shortest distance, the fastest travel time, the highest number of reviews, and a moderate ecotourism suitability score. Batuangus Beach ranked second with a preference value of 0.5277, supported by its high rating and high number of reviews. Pantai Tanjung Merah and Pantai Lilang ranked third and fourth, respectively.

Example of Stage 2 Calculation

For the distance criterion, the minimum distance from favehotel Bitung was 5.3 km. The distance from favehotel Bitung to Batuangus Beach was 12.4 km. Therefore, the transformed distance value was:

$$x'_{D03,D-C3} = \frac{5.3}{12.4}$$

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$$x'_{D03,D-C3} = 0.4274$$

For the travel time criterion, the minimum travel time was 12 minutes. The travel time from favehotel Bitung to Batuangus Beach was 29 minutes. Therefore, the transformed travel time value was:

$$x'_{D03,D-C4} = \frac{12}{29}$$
$$x'_{D03,D-C4} = 0.4138$$

The preference value for Kebun Binatang Tandurusa was calculated as:

$$V_{D01} = \frac{D^-_{D01}}{D^+_{D01} + D^-_{D01}}$$
$$V_{D01} = \frac{0.3144}{0.0004 + 0.3144}$$
$$V_{D01} = 0.9989$$

This value indicates that Kebun Binatang Tandurusa was the closest alternative to the positive ideal solution in the destination selection stage.

Discussion

The results of Stage 1 show that favehotel Bitung was the best hotel alternative. Its preference value was substantially higher than those of the other hotels. This result was mainly driven by the very high number of Google Maps reviews. The Entropy method assigned a very large weight to the number of reviews because this criterion had the greatest data variation among hotel alternatives. In addition, favehotel Bitung also had the shortest distance and fastest travel time from Sam Ratulangi Airport, which strengthened its position in the ranking.

The dominance of review volume in Stage 1 indicates that digital reputation played an important role in the hotel selection model. Hotels with many reviews may provide stronger information signals to tourists because more user-generated content is available for evaluation. However, this result should be interpreted carefully. Entropy weighting reflects data variation, not direct tourist preference. Therefore, the dominance of the number of reviews occurred because the difference between the highest and lowest review counts was very large.

In Stage 2, Kebun Binatang Tandurusa became the best ecotourism destination alternative. This result was influenced by its strong performance in several criteria. It had the shortest distance from the selected hotel, the fastest travel time, and the highest number of reviews among the destinations included in the main calculation. Although its rating was lower than Batuangus Beach, rating received a very small weight because rating values among destinations were relatively similar.

The ranking of Batuangus Beach in second position shows that high rating and review volume can support a destination’s competitiveness, but accessibility remains important. Batuangus Beach had a higher rating than Kebun Binatang Tandurusa, but its distance and travel time were less favorable. Since distance and travel time had relatively large weights in Stage 2, the lower accessibility performance reduced its final preference value.

Pantai Tanjung Merah ranked third. Although it was closer than Pantai Lilang and had more reviews, its ecotourism suitability score was lower. This indicates that suitability remains relevant in the model, especially when a destination is evaluated as part of ecotourism destination selection. Pantai Lilang ranked fourth because it had the longest distance and travel time among the main destination alternatives, despite having a relatively good rating.

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The exclusion of destinations requiring boat access from the main calculation is an important methodological consideration. Lembeh Strait, Pantai Serena, Ecotourism Mangrove Lirang, and Pantai Kahona were relevant to coastal and ecotourism, but their accessibility data were not directly comparable with car-accessible destinations. Including them without comparable distance and travel time data could bias the TOPSIS calculation. Therefore, these destinations were retained as candidate alternatives but excluded from the main quantitative ranking.

Overall, the two-stage model provides a more realistic travel decision process. Instead of selecting ecotourism destinations directly from the airport, the model first selects a hotel and then uses the selected hotel as the starting point for destination evaluation. This approach reflects actual tourist behavior, where accommodation selection often precedes destination visitation. The model also demonstrates how Google Maps data can be transformed into a structured DSS framework for tourism planning.

Within this research two stage DSS has shown these results, the Stage 1 results showed that favehotel Bitung was selected as the best hotel, with a preference value of 0.9999. Therefore, favehotel Bitung was used as the starting point for Stage 2. The Stage 2 results showed that Kebun Binatang Tandurusa was the best-ranked ecotourism destination, with a preference value of 0.9989, followed by Batuangus Beach, Pantai Tanjung Merah, and Pantai Lilang. These findings indicate that the Two-Stage Entropy-TOPSIS model can provide structured recommendations for hotel and ecotourism destination selection based on Google Maps data. From a practical perspective, the results suggest that hotel and destination managers should pay attention to digital visibility on Google Maps. The number of reviews strongly influenced the results, especially in the hotel selection stage. Managers should encourage visitors to leave reviews, provide accurate location information, and maintain service quality to strengthen their online reputation. For destination managers, improving accessibility information and clearly communicating ecotourism value may help improve competitiveness in digital tourism platforms.

4. CONCLUSION

This study developed a Two-Stage Entropy-TOPSIS model for hotel and ecotourism destination selection in Bitung, North Sulawesi, Indonesia. The model was designed to reflect a more realistic tourist decision-making process, where tourists first select a hotel from the airport and then choose tourism destinations from the selected hotel as the starting point. The data were collected from Google Maps and included rating, number of reviews, distance, travel time, facility score, and ecotourism suitability score.

The first stage evaluated eight hotel alternatives in Bitung using five criteria: Google Maps rating, number of reviews, distance from Sam Ratulangi Airport, travel time from the airport, and facility score. The Entropy weighting results showed that the number of reviews was the most dominant criterion in hotel selection due to its large data variation. The TOPSIS ranking results indicated that favehotel Bitung was the best hotel alternative, with a preference value of 0.9999. Therefore, favehotel Bitung was used as the starting point for the second-stage analysis.

The second stage evaluated ecotourism destinations in Bitung using the selected hotel as the origin point. Because several destinations required boat access and did not have comparable road-based distance and travel time data, the main TOPSIS calculation included only destinations with complete numerical accessibility data. The results showed that Kebun Binatang Tandurusa ranked first, with a preference value of 0.9989, followed by Batuangus Beach, Pantai Tanjung Merah, and Pantai Lilang. Kebun Binatang Tandurusa achieved the highest rank because it had the shortest distance, fastest travel time, and

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highest number of reviews among the destination alternatives included in the main calculation.

Theoretically, this study demonstrates that the integration of Entropy and TOPSIS can be applied in a two-stage decision support model for tourism planning. The Entropy method provides objective criteria weights based on data variation, while TOPSIS produces alternative rankings based on closeness to the positive ideal solution and distance from the negative ideal solution. The proposed two-stage approach contributes to decision support research by linking hotel selection and destination selection in a single sequential model.

Practically, the results can help tourists make more structured travel decisions by first selecting a suitable hotel and then identifying accessible ecotourism destinations from that hotel. The findings also provide implications for hotel and destination managers. Hotels and tourism destinations need to improve their digital visibility, maintain service quality, and encourage visitors to provide Google Maps reviews, as review volume strongly influenced the decision model. Destination managers should also provide clearer accessibility information, especially for destinations requiring boat access.

This study has several limitations. First, Google Maps data, including ratings, number of reviews, distance, and travel time, may change over time. Second, the facility score and ecotourism suitability score involved researcher judgment based on online information. Third, several destinations requiring boat access were excluded from the main quantitative ranking because their accessibility data were not directly comparable with car-accessible destinations. Future studies can improve this model by incorporating multimodal travel data, including road and boat travel time, entrance fees, operating hours, number of photos, facilities, sentiment analysis of reviews, and environmental sustainability indicators. Future research may also compare Entropy-TOPSIS with other multi-criteria decision-making methods such as SAW, VIKOR, PROMETHEE, ELECTRE, or hybrid MCDM approaches to test ranking consistency.

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