A computer-based system to support tourism in Bali, Indonesia

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Abstract. The purpose of this research is to determine a favorite tourist destination in Bali with GDSS approach. The problem that occurs in Bali is the occurrence of a significant difference in tourist visits to each of the destination object. Ranking of tourism objects as a whole allows famous tourism objects determine by tourists. The ranking process using the approach of the Group Decision Support System (GDSS), it aims to combine the decisions of several tourists. The AHP model in GDSS is used to determine the weight of each criterion in each alternative, the TOPSIS model use for individual ranking of each tourist object and the BORDA model aims to classify individual ranking. The results showed that the Tanah Lot tourist attraction was ranked first with a difference in the value of more than half with other tourism objects, such as the Goa Gajah tourist attraction has the last rank. The results of the sensitivity analysis show that cleanliness and safety criteria are vital factors of tourism objects.

1. Introduction
There is more than one hundred tourism object spread across eight regencies in Bali [1]. These tourism objects have different characteristics and categories with each other. Like natural tourism objects, such as the beach, has almost the same level of beauty and facilities, but a striking difference indicates by the number of tourist visits to these attractions. Likewise, Tanah Lot has a visit rate of one hundred thousand more each month, and this is far different from the Sanur tourism object whose visit rate is half than Tanah Lot tourism object [1]. As with other tourism objects, there is a striking difference between tourists’ visits.

To determine the assessment and ranking of each tourist object, which aims to choose the parameters that have a significant effect on tourist visits through the ranking process. The ranking determination by Travelers, where there are several categories of tourists, including Solo Tourists, Family, Culinary, Cultural, and Luxury. Tourist categorizers are base on their nature [2]. Each tourist category then in this study becomes a decision maker (DM) to decide the ranking of tourist destinations.

In the ranking process, the criteria for each criterion are first determined [3], the AHP methods are used to solve the criteria of weighting [4,5]. AHP method is a structured technique that can analyse complex decision making by determining various weight factors and accurate evaluation factors [6]. One of the advantages of the AHP method is that it can check consistency against comparison evaluations between criteria [7]. The ranking process of the weight that determines, then using the Technique for Order Preference approach by Similarity to Ideal Solution (TOPSIS) as one of the decision models of MADM can be used to give preference to managers. TOPSIS is base on the concept that the best-chosen alternative does not only have the shortest distance from the positive ideal solution.
but also has the longest distance from the negative ideal solution [8]. Besides, TOPSIS is a simple and easy to understand method for DM.

Group ranking then determines ranking Individuals from each DM, one of the group decision-making models is the BORDA Method. The method can complete group ranking by setting alternative ranking of tourist destinations based on preferential values of individual decision makers. Personal preference values for alternative tourist destinations calculate how many occupy ranking positions based on the results of the ranking weights of each DM [9]. The best choice is an alternative to have the highest accumulation of points and weight, where each alternative has points and alternative weights, from the highest to the lowest [10].

This study aims to find famous tourism objects using the AHP - TOPSIS - BORDA approach, and then make a combination of each method. The use of the three models can produce a decision that can accommodate the conclusion of the five types of tourists. Another result that is the aim of this research is the influence of each criterion on each alternative tourist destination so that the sensitivity analysis of these parameters can use.

2. Methodology

The system that will be designed and made in this research is the system group decision support (GDSS) to support takers a decision to evaluate the selection of favorite tourism objects in Bali. The evaluation process of favorite attractions in the system is done using the AHP method to determine the weight of each alternative, the TOPSIS Method (Technique for Order Preference by Similarity to Ideal Solution) to obtain individual ranking of each DM, while the voting process to choose the alternative to be taken in providing solutions to favorite tourism objects using the Borda method. Based on the results of interviews with decision-makers including Solo Travelers, Group or family Travelers tourists, Culinary Travelers, Cultural Travelers and Luxury Travelers as decision-making groups, the system needs analysis that will be built in evaluating favorite tourism objects is as follows, The ranking process of tourism objects in this paper consists of several stages, including:

- Data Preprocessing, choosing several tourism objects that are an alternative choice, determining the criteria for each alternative and determining each DM.
- Determination of weight with the AHP model, the calculation of the weight generated by each DM, by comparing each criterion in a comparison table that produces consistent values.
- Individual ranking with TOPSIS Algorithm. The ranking is processed by each DM from the weight obtained from the previous process by determining the shortest Euclidean distance from the positive ideal solution and distance.
- Group ranking using the BORDA model, this method can bring together individual ranking results, where the greatest preference for individuals has a greater chance of being an alternative group decision.

Data is needed to produce good information, because of information basically is the result of processing data inputted into the system. In this Group Decision Support System, the data source comes from:

- Internal data, is data that comes from within the organization to support the Group Decision Support System that will be designed. As for some internal data what is needed is tourism object data which is used as an alternative choice of decision, data on the assessment of each tourist object in accordance with predetermined criteria, and so on.
- External data, is data that comes from outside the organization but still has influence in creating a good decision-making system. As for some external data that influence decision making in the Group Decision Support System, among others, data on the number of tourist visits, facilities provided and other factors by asking each visitor.
2.1. Data Preprocessing

The data sampling process was carried out using a systematic random sampling technique [11], where each district was taken one of the highest numbers of visits in a year. The data used is 183 tourism objects spread over 8 regencies in Bali. Systematic random sampling results, then become alternative favorite tourism objects, shown in Table 1.

The criteria possessed by each tourism object are described in Table 2. Each DM has a different assessment of the influence of the criteria on each alternative [2,12]. In this paper using 5 DM tourists who have different criteria for each DM. Tourists are people who are not working or are on vacation and voluntarily visit other areas to get something else.

Process requirements in this research paper are needed to process input data into output in the form of expected information. Some of these processes include:

- The process of conversion between data to rating value that has been given by decision makers, and the determination of weight with the AHP model.
- The process of calculating the value data of each alternative using the TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution).
- The voting process of the preferences given by the taker's decision to use the BORDA method.

### Table 1. Alternative tourism objects.

| Variables | Tourism Object Name                  | District     |
|-----------|--------------------------------------|--------------|
| A<sub>1</sub> | Sanur Beach                         | Denpasar     |
| A<sub>2</sub> | Uluwatu                             | Badung       |
| A<sub>3</sub> | Medewi Beach                        | Negara       |
| A<sub>4</sub> | Taman Gili dan Kertha               | Klungkung    |
| A<sub>5</sub> | Besakih Tample                      | Karangasem   |
| A<sub>6</sub> | Tanah Lot                           | Tabanan      |
| A<sub>7</sub> | Tampak Sining                        | Gianyar      |
| A<sub>8</sub> | Lovina Beach                        | Buleleng     |
| A<sub>9</sub> | Penglipuran Village                 | Bangli       |

Classification of DM is based on criteria contained in Table 3. In the next assessment, each DM has a different weight from each other. Weighting is determined by hierarchical analysis, which is the purpose of the model in this study.

### Table 2. Criteria for each alternative.

| Code | Description                               | Character |
|------|------------------------------------------|-----------|
| C<sub>1</sub> | Number of tourist visitors              | Objective |
| C<sub>2</sub> | Infrastructure                           | Objective |
| C<sub>3</sub> | Objects and attractiveness of tourists   | Objective |
| C<sub>4</sub> | Service                                  | Objective |
| C<sub>5</sub> | Security                                 | Objective |
| C<sub>6</sub> | Natural disasters                        | Objective |
| C<sub>7</sub> | Comfort                                  | Objective |
| C<sub>8</sub> | Accessibility                            | Objective |
| C<sub>9</sub> | Number of Hotel                          | Objective |
| C<sub>10</sub> | Number of restaurants                    | Objective |
| C<sub>11</sub> | Attractions                              | Objective |
| C<sub>12</sub> | Promotion                                | Objective |
| C<sub>13</sub> | Distance from city center                | Objective |
| C<sub>14</sub> | Cleanliness                              | Objective |
| C<sub>15</sub> | Management of tourism objects            | Subjective |
The criteria for each DM are described in Table 3 with the DM elaboration [2], the collection of each tourist based on the characteristics of the tourists.

**Table 3. Description of each DM.**

| Category | Description               |
|----------|---------------------------|
| DM₁      | Solo Travelers            |
| DM₂      | Group or family Travelers |
| DM₃      | Culinary Travelers        |
| DM₄      | Cultural Travelers        |
| DM₅      | Luxury Travelers          |

2.2. Weight model of each DM with AHP

The Analytical Hierarchy Process (AHP) model is a multi-criteria decision-making (MCDM) method and is able to combine qualitative analysis and quantitative analysis [13], the AHP method is also a method that can solve complex multi-criteria problems [14]. The calculation model of parameter weights with AHP is to calculate the parameter weights that will be used in the selection of favorite tourism objects. The hierarchy of tourism object selection is shown in Figure 1. The hierarchical structure of tourism object selection consists of fifteen parameters to choose alternative favorite tourism objects, with 9 alternatives provided. The assessment parameters are divided into two groups, namely 12 objective parameters and 3 subjective parameters.

**Table 4. Comparative value scale.**

| Level of Interest | Definition | Description |
|-------------------|------------|-------------|
| 1                 | As important | Both elements have the same effect. Experience and assessment strongly favor one element compared to their partner. |
| 3                 | More important one over the other | Experience and decisions show preference for one activity more than others. |
| 5                 | Quite Important | Experience and decisions show a strong preference for one activity more than others. |
| 7                 | Very Important | Experience and decisions show a strong preference for one activity more than others. One absolute element is preferred compared to its partner, at the highest level of confidence. |
| 9                 | Absolute more Important | One absolute element is preferred compared to its partner, at the highest level of confidence. |
| 2,4,6,8           | The middle value between two adjacent values | When a compromise is needed. |

The relationship of each criterion to the alternative is described in Figure 1, each DM has a different criterion for each alternative which is then represented in the comparison matrix with a comparison value scale of 1-9. Giving a comparison scale value based on the conditions and the appropriate quantitative scale. Based on the concept that the best selected alternative does not only have the shortest distance from the positive ideal solution, but also has the longest distance from the negative ideal solution. In general, the TOPSIS procedure follows the steps as follows:

- Calculating normalization values, TOPSIS requires performance ratings for each Ai alternative on each normalized criterion.
• Calculating the weighted normalization value. After calculating the normalization value, the next step is to calculate the weighted normalization value by multiplying the values in each alternative dimension of the matrix with the weight given by the decision maker.
• Identify positive ideal solutions and negative ideal solutions. Positive ideal solutions and negative ideal solutions can be calculated based on the weighted normalization value.
• Calculating the distance between each alternative with a positive ideal solution and a negative ideal solution.
• Determine the value of the proximity of each alternative to the ideal solution (preference).

2.3. Ranking of individuals with TOPSIS
TOPSIS (Technique for Other Preference by Similarity to Ideal Solution) is one method that can be used for MCDM. The system is made to assist the company in choosing the offer made by another company [15,16]. The algorithm used to calculate the ranking of each DM by using the TOPSIS method, its show in Figure 1.

2.4. Group ranking with BORDA
Borda method is one of the voting determination models that can complete group decision making, which in its application each decision maker (DM) ranks based on the available alternative choices. The ranking process in the Borda method is carried out by each DM who is given an alternative choice. There are n selected candidates, the first candidate or alternative is given n points by DM.

The second candidate is given n-1 points and so on. Determination of the best winner or alternative based on the highest points. An alternative with the highest value is the material of consideration to be chosen [17,18].

The stages and the process of calculating the AHP hybrid method with Borda method based on multi decision maker analysis, include [19]:

• Each DM applies the concept of AHP calculation. Each DM carries out a comparison process in pairs of alternative criteria and evaluations.

![Figure 1. Flowchart TOPSIS process.](image-url)
• Ranking evaluation using Borda method. Alternative ranking determination is obtained from the weight value in the process of the highest alternative Ranking will get the highest points, then the next point (n-1) where n is the number of alternatives and the lowest points get 0 points.
• The alternative weight value of AHP is multiplied by the Borda method point. Add up each alternative score.
• The process of normalizing the weight of each alternative. The normalization value of weight is obtained from the total value of each alternative score/overall accumulated total score.

3. Results and discussion
The results of the study indicate the weight that is generated by the AHP model, and then the weight value is used in the ranking of individuals using the TOPSIS model.

| Code | DM1 | DM2 | DM3 | DM4 | DM5 |
|------|-----|-----|-----|-----|-----|
| C1   | 0.104181885 | 0.095449306 | 0.094829471 | 0.009051407 | 0.095659895 |
| C2   | 0.089896227 | 0.103426388 | 0.102754751 | 0.010625753 | 0.102123999 |
| C3   | 0.122952575 | 0.12060957 | 0.12126831 | 0.014802126 | 0.118234435 |
| C4   | 0.132295695 | 0.10964246 | 0.126114637 | 0.013827519 | 0.127219026 |
| C5   | 0.087210353 | 0.091138968 | 0.091185369 | 0.00831054 | 0.083863773 |
| C6   | 0.068196808 | 0.075165625 | 0.073258931 | 0.005506553 | 0.071929614 |
| C7   | 0.062667078 | 0.073221652 | 0.061640288 | 0.004513404 | 0.06609682 |
| C8   | 0.058034629 | 0.055684771 | 0.052044838 | 0.001140173 | 0.053951371 |
| C9   | 0.06094496 | 0.061242892 | 0.063722809 | 0.003902569 | 0.061378012 |
| C10  | 0.043146539 | 0.043357463 | 0.043075905 | 0.001867662 | 0.043453122 |
| C11  | 0.035835348 | 0.037713617 | 0.035776683 | 0.00134268 | 0.036089981 |
| C12  | 0.033711827 | 0.03876629 | 0.033656639 | 0.00140173 | 0.033951371 |
| C13  | 0.028790357 | 0.03731186 | 0.028743225 | 0.00096543 | 0.02899493 |
| C14  | 0.040382052 | 0.03697207 | 0.040315943 | 0.001491577 | 0.040668991 |
| C15  | 0.031664038 | 0.027290879 | 0.031612202 | 0.000862725 | 0.031889031 |

The Decision Support System for ranking tourism objects utilizes the TOPSIS and BORDA methods as a determinant model for each alternative. The steps taken are:

• Providing an assessment of each tourism object to determine alternative tourism objects that are favorite according to predetermined criteria.
• Calculating the value of each alternative to get a ranking from each alternative uses the TOPSIS method.
• Aggregating preferences are given by decision makers using the Borda method to find alternative solutions for choosing favorite tourism objects.

According to the steps above, the Group Decision Support System model could determine the outcome of each DM.

Table 5 shows the results of the criteria comparison table in the form of DM weighting. The use of weighting values based on the coefficient ratio (CR) value is consistent, CR is considered to be of consistent value if the value is less than 1%. There is a difference between the weighting criteria of each DM.

Table 6 shows the ranking results from each DM, where solo and culinary tourists prefer Tanah Lot beach as their favorite destination, while tourists and families and culture prefer Siring as a favorite destination. The results of the study indicate the weight that is generated by the AHP model, and then the weight value is used in the individuals ranking using the TOPSIS model.
Luxury travelers prefer Penglipuran Village as their favorite destination. Medewi beach, Uluwatu, and Lovina beaches become tourist destinations that are less favored by tourists.

Table 6. Ranking results of each DM.

| Code | DM1 | DM2 | DM3 | DM4 | DM5 |
|------|-----|-----|-----|-----|-----|
| A1   | 7   | 7   | 7   | 8   | 7   |
| A2   | 8   | 8   | 8   | 9   | 6   |
| A3   | 9   | 9   | 9   | 7   | 8   |
| A4   | 5   | 5   | 5   | 5   | 5   |
| A5   | 3   | 4   | 4   | 6   | 4   |
| A6   | 1   | 2   | 1   | 3   | 3   |
| A7   | 2   | 1   | 2   | 1   | 2   |
| A8   | 4   | 3   | 3   | 2   | 9   |
| A9   | 6   | 6   | 6   | 4   | 1   |

Table 7 describes group ranking, where tourism objects appear to be favorite tourist objects and then followed by Tanah Lot and Lovina beaches, and Medewi beach becomes a favorite tourist attraction compared to others. Tourists are more likely to choose the criteria for infrastructure, security, and accessibility to be the main factor in choosing a tourism object. Determination of these criteria can be seen from the points given by each traveler in the decision table in the form of values 3, 5 and 7.

Table 7. Group ranking results with BORDA.

| Code | DM1 | DM2 | DM3 | DM4 | DM5 | Value | Ranking |
|------|-----|-----|-----|-----|-----|-------|---------|
| A1   | 3   | 3   | 3   | 2   | 3   | 14    | 7       |
| A2   | 2   | 2   | 2   | 1   | 4   | 11    | 8       |
| A3   | 1   | 1   | 1   | 3   | 2   | 8     | 9       |
| A4   | 5   | 5   | 5   | 5   | 25  | 5     | 5       |
| A5   | 7   | 6   | 6   | 4   | 1   | 24    | 6       |
| A6   | 9   | 8   | 9   | 7   | 7   | 36    | 2       |
| A7   | 8   | 9   | 8   | 9   | 8   | 42    | 1       |
| A8   | 6   | 7   | 7   | 8   | 6   | 34    | 3       |
| A9   | 4   | 4   | 4   | 6   | 9   | 27    | 4       |

Tourists are more likely to choose the criteria for infrastructure, security, and accessibility to be the main factor in choosing a tourism object. Determination of these criteria can be seen from the points given by each traveler in the decision table in the form of values 3, 5 and 7.

4. Conclusion and future work

In this study ranking of tourism objects using the AHP TOPSIS and BORDA models. The use of the AHP model aims to obtain the weight of each criterion, where the resulting weights differ between each DM. The TOPSIS model produces individual rankings for each DM by producing Tanah Lot, Tampak Siring and Lovina Beach tourist destinations to become a favorite destination for every traveler. Group ranking is generated using the approach of the BORDA method, producing tourist destinations Looks like siring is a favorite tourist attraction and Medewi beach is a less favorite tourist attraction than others. Determination of tourism criteria is directed to the criteria of facilities and infrastructure, security and accessibility in determining favorite tourism objects.

In the future research, we can put weights to the BORDA model. Each DM has a different weight from the other, so that the voting conducted by all DM produces the value of the majority of the existing tourists. In the future research needs to be carried out a sensitivity test by changing the value obtained in the TOPSIS model so that it could analysis the comparison and the influence of each alternative.
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