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Mobile-Based Decision Support System for Recommending Tourism Attraction Using MAGIQ-ARAS Methodology

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ABSTRACT

Tourism in Bali faces challenges such as overcrowding, poor management, and diverse visitor preferences, which hinder effective decision-making for tourist destinations. This study introduces an Android-based DSS using the MAGIQ-ARAS. The MAGIQ method simplifies the weighting process, while the ARAS method evaluates alternatives to produce utility-based rankings. Together, MAGIQ-ARAS provide a structured approach for generating tourist recommendations tailored to user preferences. The research follows a combination of the CRISP-DM framework for data preparation and the Waterfall Model for system development. Field studies, interviews, and literature reviews informed the design of a mobile application that integrates MAGIQ and ARAS. Black-box testing verified functionality, and accuracy testing using a confusion matrix evaluated the alignment between recommendations and user preferences. The results demonstrate the system's effectiveness, achieving 90% accuracy in matching recommendations with user preferences. Black-box testing confirmed that all features, including preference weighting and interactive navigation, operated as intended. The system simplifies MCDM and enhances user satisfaction through its efficient and user-friendly interface. The study concludes that the MAGIQ-ARAS-based mobile application offers a reliable solution for tourist recommendations. Future work should explore real-time data integration and expand application to other tourism regions to enhance adaptability and usability.

Keywords: Tourism; DSS; MAGIQ; ARAS; Mobile

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1. INTRODUCTION

Tourists in determining their travel destinations are significantly influenced by cognitive biases in their decision-making [1]. In Bali, various tourism sectors have been developed to address these cognitive biases. The development of the tourism industry not only provides centralized services and comfort but also presents various centralized weaknesses. Tourist areas become congested, experience traffic jams, and face issues such as waste management and rising crime rates [2]. Tourists desire to engage in centralized tourism; however, at the same time, they seek tranquility in the sacredness and mystique of Bali. This anomaly is sometimes difficult for tourists to manage, making the presence of tour guides or online information services that can provide recommendations for tourist destinations essential.

Decision Support Systems (DSS) can serve as a solution in providing recommendations to tourists [3]–[5]. A DSS is a computer-based system that integrates data and analytical models to provide alternative solutions and recommendations that can assist users in making better decisions [6]–[8]. With accurate and relevant information support, DSS reduces uncertainty and enhances the effectiveness of the decision-making process [9]–[12]. DSS is designed to help individuals or groups formulate problems, collect data, analyze information, and present alternative solutions or decision options [13]–[16]. DSS is beneficial for better decision-making, time efficiency, complex data processing, flexibility, and support in various uncertain situations [17]–[19]. DSS has advantages for deeper analysis, interactivity, data-driven decision-making, ease of use, and improved accuracy [20]–[22].

The expectation of tourists for faster services compared to precise accuracy in criterion weight distribution has led to the need for the previous studies that utilized AHP and FUCOM methods to be updated [23]–[25]. This research plans to use the Multi-Attribute Global Inference of Quality (MAGIQ) method for weighting. MAGIQ was first introduced by James D. McCaffrey; this method uses a weighting concept similar to Rank Order Centroid (ROC), which assigns values based on the priority order of criteria [26]. This method has a simpler process, and MAGIQ implements the ranking of criteria and sub-criteria that can accelerate and simplify the weighting process compared to other weighting methods, which makes this method attractive for use in criterion weighting [27]–[29]. The MAGIQ method has a simpler, easier, and faster process, and respondents do not need to pay attention to statistics or have a deep understanding of management. This is advantageous for tourists who do not require managerial understanding in providing criterion weights and do not use specific numbers or scales.

The Additive Ratio Assessment (ARAS) method, introduced by Zavadskas and Turskis in 2010, is designed to select the best alternatives based on multiple attributes. The final ranking of alternatives is determined by calculating the utility level of each alternative [30]. This method has demonstrated versatility in various applications, including recruitment and personnel selection, economics, tourism, and the ranking of factoring companies [31].

Research comparing ARAS with methods such as CoCoSo and RAFSI has highlighted ARAS's simplicity and speed, making it particularly suitable for the chosen case study [32]. Consequently, this study employs the MAGIQ-ARAS method, integrated into an Android-based Decision Support System (DSS), to recommend tourist destinations. This approach represents an innovative system designed to assist tourists in selecting destinations aligned with their preferences by leveraging the MAGIQ-ARAS methodology. Previous studies on DSS, tourism, and the MAGIQ-ARAS method have consistently shown promising results [33]–[37].

MAGIQ, compared to traditional decision-making tools like AHP or TOPSIS, offers distinct advantages for ease of use and efficiency, particularly for novice decision-makers. MAGIQ utilizes the Rank Order Centroid (ROC) weighting approach, which accelerates the decision-making process. While AHP provides a more rigid structure, it risks failing to achieve the required consistency rate of 10%, necessitating recalculations and potentially slowing decision-making. Despite being less rigid than AHP, MAGIQ's flexibility and speed make it well-suited for scenarios like selecting tourist destinations, where slight inconsistencies in weighting do not significantly affect outcomes.

ARAS stands out among traditional methods like SAW and WP due to its balance between rigor and efficiency. Although ARAS is less rigid than TOPSIS, it offers a shorter and more streamlined process, enabling quicker decisions without sacrificing reliability. ARAS's speed is comparable to SAW while providing a more robust calculation framework, making it an ideal choice for applications requiring rapid yet precise assessments, such as ranking tourist destinations. Additionally, ARAS's relatively recent introduction necessitates further validation, which underscores its use in this research.

Based on these considerations, this study presents a Mobile-Based Decision Support System for recommending travel destinations using the MAGIQ-ARAS methodology. The innovation lies in the Android-based system's ability to combine the strengths of MAGIQ's ease of use and ARAS's efficient yet rigorous assessment process, addressing tourists' needs for swift and tailored recommendations. This system aims to bridge gaps in traditional methods by delivering a user-friendly, accurate, and adaptive tool for decision-making in tourism.

2. RESEARCH METHOD

This research employs a research flow integrated with the CRISP-DM framework for a data science approach and the Waterfall Model for implementing web and mobile-based information systems. The modeling stage in the CRISP-DM framework and the implementation stage in the Waterfall Model are related to the use of the MAGIQ-ARAS method in solving Decision Support Systems (DSS). The research flow integrated with CRISP-DM framework and waterfall model can be view at Figure 1.

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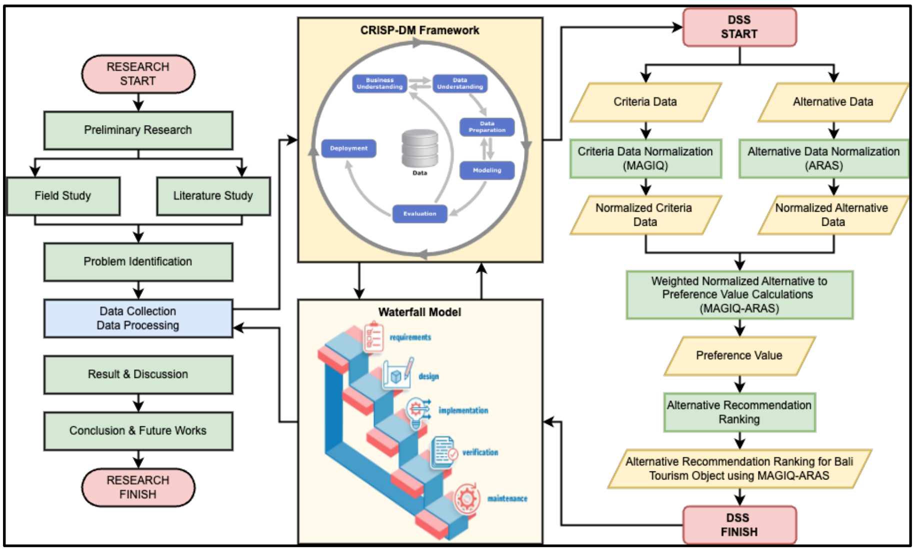

Figure 1. Research Flow Integrated with CRISP-DM Framework and Waterfall Model

The research methodology begins with a preliminary study integrated with business understanding, designed to evaluate the conditions of tourist destinations in Bali, identify key challenges, and analyze the needs and expectations of tourists. This stage involves field studies supported by participant data to enhance reliability and validity. For this research, participant demographics include both domestic and international tourists, reflecting the diverse visitor profile in Bali. According to the Indonesian Central Bureau of Statistics (BPS), Bali hosted 5,273,258 international tourists and 9,877,911 domestic tourists in 2023, compared to 2,155,747 international and 8,052,974 domestic visitors in 2022. This substantial volume of visitors highlights the importance of developing innovative approaches to mitigate overtourism by recommending less mainstream destinations to balance tourist distribution effectively.

This study recognizes that traditional decision-making methodologies, such as AHP, SAW, or TOPSIS, are better suited for technical and high-level business applications. However, these methods often present challenges for general users, such as tourists, who are typically "nothing-to-lose" decision-makers. These users seek quick, flexible recommendations and are open to new experiences, even if the decisions made are not perfectly optimal. The MAGIQ-ARAS method addresses this gap by offering a decision-making approach that is both efficient and intuitive, aligning with the behavioral characteristics of tourists.

The output of this stage is a comprehensive report that includes situation analysis, a detailed assessment of Bali's tourism landscape, including visitor profiles and destination conditions; problem identification, get insights into challenges faced by tourists, such as overtourism or limited access to alternative destinations; and potential solutions, giving recommendations tailored to the needs of tourists, emphasizing less mainstream destinations to reduce pressure on overvisited areas. By using MAGIQ-ARAS, this study offers a decision-support framework that ensures tourists receive quick and adaptive recommendations aligned with their preferences, while also supporting sustainable tourism practices in Bali. This approach balances the technical demands of decision-making systems with the practical needs of non-technical users, making it a relevant, user-friendly, and impactful tool for modern tourism challenges.

Next, a field study is conducted through direct observation, interviews, and Focus Group Discussions (FGDs) to gather more in-depth data and insights about tourists' needs. The field data collected includes interview notes, observations, and visual documentation, serving as the output for this stage, with achievement indicators based on the relevance and accuracy of the collected data. The subsequent stage is a literature review that analyzes various sources such as scientific journals, books, and publications related to the selection of tourist destinations. The resulting literature summary encompasses relevant theories and findings, along with achievement indicators reflecting a deep understanding of theoretical frameworks and methodologies. Following this, the problem identification process is carried out by analyzing data from the preliminary study, field study, and literature to identify the main issues in selecting tourist destinations. The output consists of a clearly identified list of problems, which serves as an achievement indicator.

The data collection and processing stage involves gathering further data necessary for the development of a tourist destination selection application. This includes collecting user preference data and technical data related to the company's operations, as well as identifying functional and non-functional requirements. The expected output is complete and structured data, ready for analysis and development.

Subsequently, in the Waterfall model, the design phase includes designing the application system architecture, user interface, and database structure based on identified needs. The resulting application design becomes the output, with achievement indicators reflecting the design's suitability for user needs. During the implementation stage, the application code is developed based on the approved design, including integration with the Decision Support System (DSS). The output of this stage is an implemented application with the designed features, where the achievement indicator is the basic functionality that meets the specifications.

Then, an analysis of results and discussion is conducted by analyzing data from various studies to identify patterns, trends, and implications in the application development. Application testing is performed to ensure that all features function properly and meet user needs. The output of this stage includes the analysis of research results, discussions about the implications of findings, and a testing report that encompasses results and recommendations for improvement. Achievement indicators are marked by in-depth analysis and a well-tested application. Finally, the conclusion and recommendation stage involve summarizing the research findings and providing practical recommendations for the development of the application. The expected output is a summary of the conclusions and recommendations for the next stages, with achievement indicators in the form of clear conclusions and the completion of promised outputs, including reports, web and Android applications, scientific journal articles, and Intellectual Property Rights (IPR).

3. RESULTS AND DISCUSSION

The results of this research will follow the research flow that has been explained previously in the research method section.

3.1. Business Understanding, Data Understanding and Data Preparation Phase Result

Uncoordinated tourism management in Bali has become a serious issue due to the lack of coordination between the government and stakeholders. This situation has resulted in ineffective management and a lack of a shared vision for tourism development, leading to uncontrolled growth. Additionally, "over-tourism" has negatively impacted the local environment and culture, disrupted the daily lives of residents and burdening traditional livelihoods. Low awareness of tourism issues among visitors poses serious challenges. Many tourists arrive without understanding the importance of preserving local culture and the environment. A lack of education on ethical tourism practices leads to negative tourist behaviors. Addressing structural poverty and income inequality is crucial, as the economic gap between those benefiting from tourism and other residents continues to widen. Inadequate long-term planning has made tourism development unsustainable. This has created confusion over tourism direction, negatively affecting Bali's economy and environment. Many tourism managers lack the necessary skills in strategic management, marketing, finance, and business development. To address these issues, research utilizing Decision Support Systems (DSS) is needed. Data-driven decision-making through DSS can help identify and evaluate solutions for more sustainable tourism development.

Data collection has been conducted from various sources, including the Bali Provincial Tourism Office. This data includes tourist areas, attractions, star-rated hotels, budget accommodations, restaurants, bars, travel agencies, and tourist villages, along with international tourist arrival statistics. The primary data focuses on tourist areas and attractions in Bali. This information will help recommend options that align with tourist preferences. Additional data will support this study or contribute to related research using DSS. The research will utilize data on tourist areas and attractions in Bali up to 2022. Based on this data, recommendations will guide tourists in choosing attractions that suit their preferences. Criteria for evaluating attractions include natural conditions, environmental factors, cultural significance, infrastructure, organizational structures, human resources, community life, and accessibility. Surveys will score each attraction based on these criteria.

The study will also assess tourist preferences for determining criteria. Three tourists will be sampled for weighting using the MAGIQ method. Their personas and weighting hierarchy will be detailed in accompanying tables. After gathering data on tourist attractions, visitor data will also be collected to inform decision-making. Criteria weighting will use the MAGIQ method, with adjustments made during the Data Preparation stage.

The Data Preparation phase will translate previous data into a format ready for analysis and calculation. This research will use a total of 355 data points, including survey results to score each attraction across eight criteria. The data will include information on population density and distance from tourism centers. This research will also collect survey results from tourists to understand their criteria preferences. The weighting process will be documented, and personas for decision-makers will be summarized in relevant tables. Finally, alternative data for each tourist attraction in Bali will be identified. This data will focus on distances from tourism centers in each district and will be prepared for calculations during the modeling phase. Here is a sample of the data used for this research.

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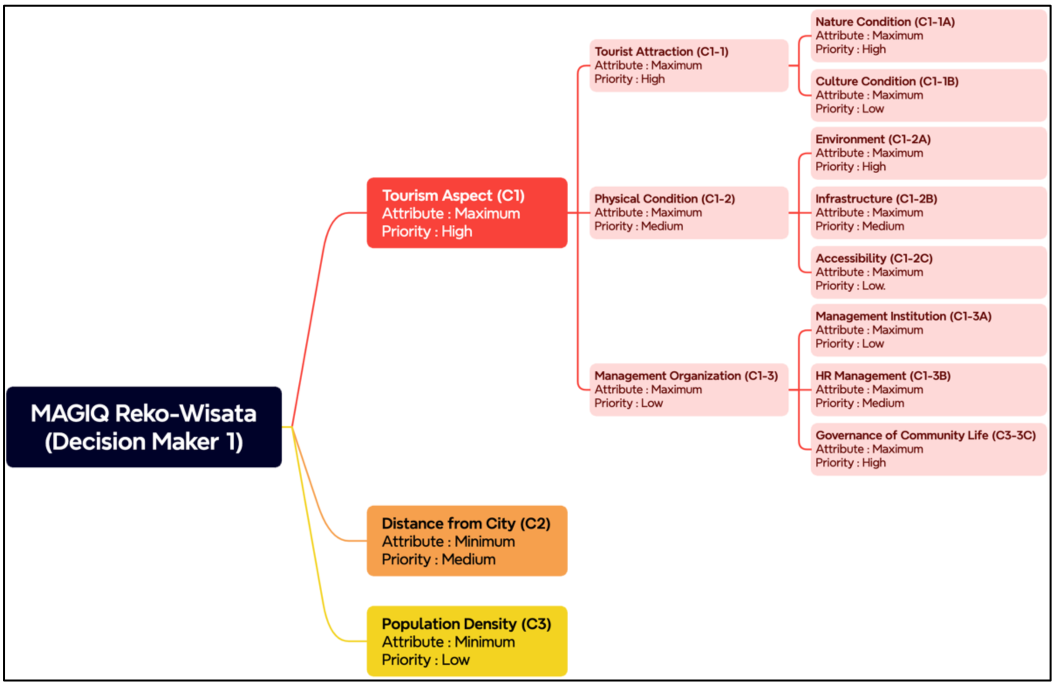

Figure 1. MAGIQ Reko-Wisata Flowchart

Table 1. Alternative Value in Level 1 Hierarchy

Alternative Code	Tourism Attraction	C1	C2	C3
Alt-001	Air Terjun Nungnung	-	48,6	270
Alt-002	Alas Pala Sangeh	-	28,9	1436
Alt-003	Bali Elephant Camp	-	34,8	270
…	…	…	…	…
Alt-349	Yeh Panas dan Hutan Bambu Angseri	-	24,5	528
Alt-350	Yeh Panes Belulang	-	20,8	241
Alt-351	Yeh Panes Penatahan	-	16,9	357

Table 2. Alternative Value in Level 3 Hierarchy

Alternative Code	C1-1A	C1-1B	C1-2A	C1-2B	C1-2C	C1-3A	C1-3B	C1-3C
Alt-001	38	46	34	13	8	18	12	20
Alt-002	39	56	34	15	10	20	12	21
Alt-003	35	44	30	14	10	18	13	20
…	…	…	…	…	…	…	…	…
Alt-349	36	50	32	14	8	19	13	20
Alt-350	33	50	32	15	9	18	12	20
Alt-351	34	49	32	15	9	18	12	19

3.2. Modeling Phase Result

According to Figure 1, the MAGIQ visualization depicts the hierarchical weighting of criteria using the Rank Order Centroid (ROC) approach. The weighted values of these criteria are further processed using the ARAS method in a series of structured steps. The initial step involves constructing an optimal alternative matrix to serve as a benchmark for comparison. Following this, alternatives at Level 3 undergo normalization using the ARAS method. This normalization process adjusts the alternative values to ensure comparability across criteria. The normalized values are then combined with the criterion weights calculated through the MAGIQ method, producing weighted normalized alternatives.

Subsequently, the optimization values and utility values are determined. The utility values calculated at Level 3 are utilized as input for the alternatives at Level 2, where the same calculation steps are repeated. These values are then propagated to Level 1, completing the hierarchical process. The final step involves identifying the utility values at the top level, with the highest utility value representing the most optimal recommendation from the MAGIQ-ARAS model. This process ensures a comprehensive and systematic evaluation, as demonstrated by the utility values generated based on the weighting provided by Decision Maker 1 using the MAGIQ-ARAS methodology.

Table 3. Tourism Attraction Recommendation using MAGIQ-ARAS

Alternative Code	Tourism Attraction Name	Utility Value	Rank	Regency
Alt-001	Air Terjun Nungnung	0,2208	Rank 104	Badung
Alt-002	Alas Pala Sangeh	0,1841	Rank 269	Badung
Alt-003	Bali Elephant Camp	0,2230	Rank 95	Badung
Alt-004	Bumi Perkemahan Blahkiuh	0,1694	Rank 345	Badung
Alt-005	Desa Wisata Baha	0,1800	Rank 300	Badung
…	…	…	…	…
Alt-347	Tanah Lot	0,1930	Rank 231	Tabanan
Alt-348	Ulun Danu Beratan	0,2062	Rank 154	Tabanan
Alt-349	Yeh Panas dan Hutan Bambu Angseri	0,1935	Rank 228	Tabanan
Alt-350	Yeh Panes Belulang	0,2350	Rank 75	Tabanan
Alt-351	Yeh Panes Penatahan	0,2152	Rank 123	Tabanan

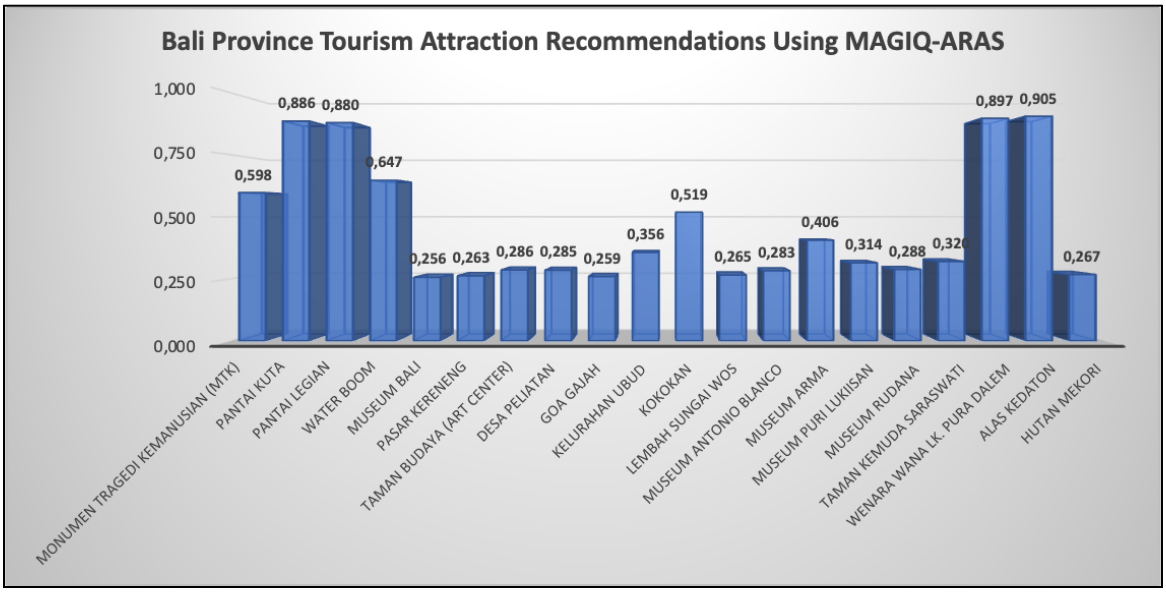

Figure 2. Top 20 Tourism Recommendations Using MAGIQ-ARAS Chart

The manual calculation model of MAGIQ-ARAS has been integrated into a web-based application for back-end processing and an Android-based application for the front-end interface. Presented below are several screenshots showcasing the Android application developed as part of this implementation.

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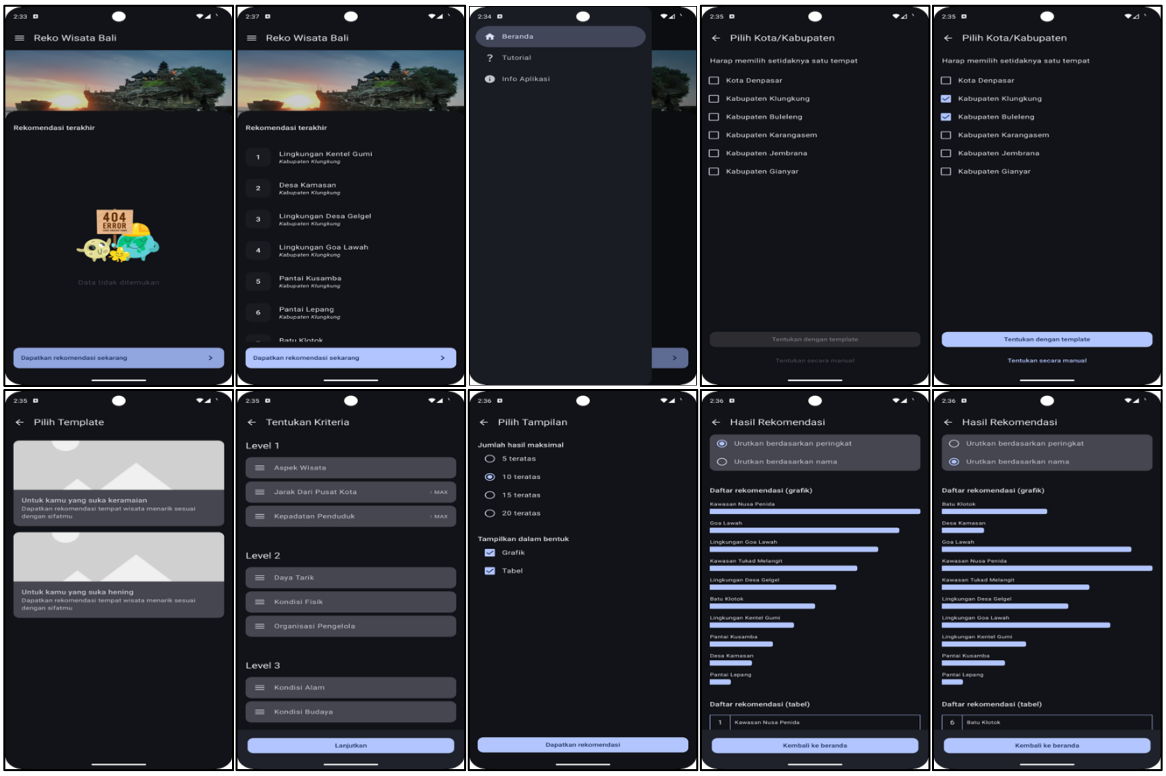

Figure 3. Android Apps Screenshot Sample for MAGIQ-ARAS DSS

3.3. Evaluation Phase Result

The evaluation phase, integrated with the verification phase within the Waterfall Model, encompasses two distinct types of testing. In the context of data science, accuracy testing is conducted to assess the effectiveness of decision-making processes within the Decision Support System (DSS). Meanwhile, in the realm of software engineering, the system undergoes black-box testing to ensure functionality.

Accuracy testing is specifically performed using the confusion matrix method, designed to evaluate the alignment between the DSS-generated recommendations and the preferences of decision makers (DMs). This testing involves 20 recommended tourist attractions (DTWs) produced by the DSS, from which each DM selects their top 5 preferred DTWs. The evaluation criteria for the confusion matrix categorize results into four types: True Positive (TP), when a recommendation appears in both the top 5 DSS recommendations and the DM's top 5 choices; False Positive (FP), when a recommendation is not in the top 5 DSS recommendations but is included in the DM's top 5 choices; False Negative (FN), when a recommendation is in the top 5 DSS recommendations but not chosen by the DM; and True Negative (TN), when a recommendation is outside both the DSS top 5 recommendations and the DM's top 5 choices.

For instance, DM1 selected tourist destinations located in the regions of Denpasar, Badung, Gianyar, and Tabanan. A detailed comparison of the data for each DM and a summary of the confusion matrix results provide insights into the system's accuracy and alignment with user preferences. The accuracy test results on DM1 reached 90% because TP and TN reached 18 points out of 20 recommended tourism attractions

Table 4. Comparison Results of Predicted and Actual Rankings for DM1

No	Tourism Attraction Name (DM 1)	Rank		Top 5		No	Tourism Attraction Name (DM 1)	Rank		Top 5	
		DSS	DM	DSS	DM			DSS	DM	DSS	DM
1	Monumen Tragedi Kemanusian (MTK)	6	1	No	Yes	11	Kokokan	7	20	No	No
2	Pantai Kuta	3	1	Yes	Yes	12	Lembah Sungai Wos	17	20	No	No
3	Pantai Legian	4	1	Yes	Yes	13	Museum Antonio Blanco	15	20	No	No
4	Water Boom	5	20	Yes	No	14	Museum Arma	8	20	No	No
5	Museum Bali	20	20	No	No	15	Museum Puri Lukiisan	11	20	No	No
6	Pasar Kereneng	18	20	No	No	16	Museum Rudana	12	20	No	No
7	Taman Budaya (Art Center)	13	20	No	No	17	Taman Kemuda Saraswati	10	20	No	No
8	Desa Peliatan	14	20	No	No	18	Wenara Wana LK. Pura Dalem	2	1	Yes	Yes
9	Goa Gajah	19	20	No	No	19	Alas Kedaton	1	1	Yes	Yes

No	Tourism Attraction Name (DM 1)	Rank		Top 5		No	Tourism Attraction Name (DM 1)	Rank		Top 5	
		DSS	DM	DSS	DM			DSS	DM	DSS	DM
10	Kelurahan Ubud	9	20	No	No	20	Hutan Mekori	16	20	No	No

Table 5. Confusion Matrix Recapitulation Results for DM1

Confusion Matrix		Predicted (DSS)	
		True	False
Actual (DM 1)	True	4 (True Positive)	1 (False Negative)
	False	1 (True Negative)	14 (True Negative)

Black-box testing is conducted to ensure that each feature within the MAGIQ-ARAS-based tourist attraction recommendation application (DTW) functions according to the specified requirements. This testing method involves observing the system's output or behavior in response to various inputs without examining the application's internal code or structure. Each test scenario is designed to verify that the application meets the expected functional requirements of users, including ease of navigation, accurate information display, and a recommendation process aligned with user preferences. The test results are presented in Table below.

Table 6. Black Box Testing Result for Reko-Wisata Apps

No	Test Scenario	Expected Outcome	Actual Outcome	Consistency
1	Access the main page of the application, both on web and mobile	The main page opens, displaying a list of options to select travel preferences or perform manual weighting	The main page opens as designed, displaying the expected options	Pass
2	User selects a district on the "Select District" page	The system displays a list of tourist attractions (DTWs) from the selected district	The system successfully displays DTWs from the selected district	Pass
3	User attempts manual weighting to set preferences	The system allows the user to input preference weights for the available criteria	Manual weighting is successfully performed, and the system accepts user input	Pass
4	Save the preference weights input on the manual weighting page	The system saves the user's preference weights and displays a success notification	Preference weights are successfully saved, and the notification appears as expected	Pass
5	User requests recommendations based on the set preference weights	The system generates a list of DTW recommendations according to the entered weights and displays the ranking	DTW recommendations appear as per the input weights, with rankings displayed	Pass
6	Access the recommendations page with ranking and name display options	The system displays recommendations in two views: by ranking and by name	Recommendations appear according to the display setting chosen by the user	Pass
7	Use the search feature on the DTW recommendations page	The system displays DTWs matching the entered keyword	Search is successful, and the system displays DTWs matching the keyword	Pass
8	Reset preference weights on the manual weighting page	The system resets all preference weights to their initial or default values	Preference weights are successfully reset to default values	Pass
9	User presses the "Back" button on the recommendations page to return to the weighting page	The system returns the user to the manual preference weighting or district selection page	User is successfully returned to the previous page as expected	Pass
10	Access detailed information on a specific DTW from the recommendation list	The system displays DTW details, including description, location, and other relevant information	DTW details are displayed completely and accurately according to available data	Pass
11	Press the "View Map" button on the DTW information page	The system opens a map application (Google Maps) and displays the DTW location	The map application opens with the selected DTW location	Pass
12	User tries to access the weighting page without selecting a district first	The system provides a notification prompting the user to select a district first	Notification appears prompting the user to select a district first	Pass
13	User tries to access a page without login or required authorization (if applicable)	The system redirects the user to the login/authorization page or displays an access restriction notification	The user is redirected to the login page or a restriction notification appears	Pass
14	Load the application on various mobile devices with different resolutions	The application adapts responsively and displays a neat interface across different screen resolutions	The application is responsive and displays a clean interface across tested devices	Pass
15	Close the application or return to the main menu while on the recommendations page	The system allows the user to return to the main page without losing data or settings	The user successfully returns to the main page with settings intact	Pass

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No	Test Scenario	Expected Outcome	Actual Outcome	Consistency
16	Access the help or information page on application usage (if the feature exists)	The system displays a guide to using the application or relevant additional information	The help page appears as expected	Pass
17	User attempts to set preferences with invalid weight values (below or exceeding limits)	The system displays an error message or warning to ensure weight values are within the valid range	The system provides a warning that the weight values are invalid	Pass

Based on the results of the black-box testing conducted, the system has met the expectations set by the researchers, allowing it to proceed to the user acceptance testing phase, which will be conducted by the users, in this case, the Decision Makers (DM).

4. CONCLUSION

The implementation of an Android-based Decision Support System (DSS) using the MAGIQ-ARAS method for determining tourist destinations in Bali successfully integrates tourism data and user preferences. The system effectively provides relevant destination recommendations based on multi-criteria evaluation, facilitating users in selecting destinations aligned with their preferences and needs. Performance testing demonstrated high effectiveness in terms of speed and accuracy, with the MAGIQ-ARAS method adeptly managing diverse criteria complexities and improving user satisfaction. To enhance user experience, it is recommended to update the application interface with interactive features such as maps and enriched destination visuals. Integrating real-time data, such as weather, tourist density, and travel trends, is suggested to improve recommendation accuracy. Future research should explore the flexibility of the MAGIQ-ARAS method in other tourism regions beyond Bali to broaden its applicability.

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