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Knowledge-Based Recommendation for Mobile Tourism Venue Rental: Development, Black Box Testing, and Usability Evaluation

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Abstract

The digital transformation of public services has increased the need for mobile applications that provide accessible, efficient, and user-oriented tourism venue rental services. However, the existing web-based rental service at BLUD UPT Teratai Mas does not fully accommodate users who predominantly access public services through smartphones and does not provide decision support for selecting venues according to specific activity requirements. This study developed a mobile tourism venue rental application integrated with a knowledge-based recommendation system. The recommendation mechanism evaluates four criteria, namely activity type, participant capacity, required facilities, and location preference, using transparent expert-defined scoring rules and weighted similarity calculations. Schedule availability is subsequently applied as a mandatory constraint to distinguish venue suitability from rental feasibility. The application was developed using the Rapid Application Development methodology, with Flutter as the mobile framework, Laravel as the REST API backend, and MySQL as the database management system. Functional evaluation was conducted through 152 Black Box Testing scenarios covering positive, negative, validation, boundary-value, authorization, and exception conditions. The results showed that 144 scenarios produced the expected outputs, resulting in a functional success rate of 94.74%. User Acceptance Testing involving 65 respondents produced an overall acceptance score of 86.2%, which was classified as very good. These findings indicate that the application generally meets its functional requirements and is positively accepted by the evaluated users. The integration of mobile access, transparent recommendation rules, schedule verification, rental submission, and administrative data management provides practical decision support for tourism venue selection and rental services at BLUD UPT Teratai Mas.

Keywords: knowledge-based recommendation; mobile application; tourism venue rental; Rapid Application Development; Black Box Testing; usability evaluation.

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1. Introduction

Digital transformation in public services involves not only converting conventional procedures into electronic formats but also redesigning administrative processes, service delivery, and interactions between institutions and citizens. When supported by institutional readiness, inclusive access, stakeholder participation, and user-oriented design, digital services can improve efficiency, accessibility, transparency, and public value. However, these benefits may remain limited when services are difficult to access, underutilized, or poorly aligned with citizens' actual needs (Tangi et al., 2021; Scupola & Mergel, 2022; Hyytinen et al., 2022; Lythreatis et al., 2022; Buyannemekh et al., 2024; Yang et al., 2024).

Mobile applications provide an important channel for extending digital services because users can obtain information and complete service activities regardless of location and conventional office hours. In tourism, mobile applications support destination discovery, planning, comparison, reservation, and booking. Their effectiveness depends on information quality, usability, responsiveness, and the ability to assist users during decision-making rather than merely

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reproducing website functions on a smaller interface (Camilleri et al., 2023; Nautiyal et al., 2023; Putra et al., 2024).

Tourism venue rental is a multicriteria decision problem because applicants must consider activity type, participant capacity, facilities, location, and schedule availability before submitting a request. Digitalizing the submission form alone does not simplify the comparison of venues with different characteristics. Recommender systems can reduce information overload by filtering unsuitable alternatives and ranking venues according to explicit user requirements. Knowledge-based approaches are particularly suitable when recommendations depend on structured domain knowledge, operational rules, constraints, and venue attributes rather than historical ratings or large-scale interaction data (Al Fararni et al., 2021; Roy & Dutta, 2022; Cepeda-Pacheco & Domingo, 2022; Rokhsaritalemi et al., 2022; AlSaeed, 2023; Gamidullaeva et al., 2023; Ivanova & Wald, 2023).

BLUD UPT Teratai Mas currently provides tourism venue rental services through a web-based platform. Preliminary interviews and requirement analysis identified two practical limitations. First, the platform does not fully accommodate users who predominantly access public services through smartphones. Second, applicants must manually compare tourism venues because the existing system does not provide recommendations based on activity requirements, participant capacity, facilities, location preferences, and schedule availability. These limitations may lead to unsuitable venue selection, application revision, or rejection during administrative verification. Therefore, a mobile decision-support service is required to complement the existing platform. These problems are consistent with the initial interviews and requirement analysis documented in the research report.

Previous studies have advanced mobile tourism applications and tourism recommender systems through multidimensional ratings, smart-tourism infrastructure, hybrid filtering, contextual modelling, intelligent information services, and sustainable tourism applications. However, mobile tourism studies generally emphasize information access, interface quality, reservations, and user experience, whereas recommender-system studies primarily examine destination ranking, personalization, prediction accuracy, or algorithmic performance (Nilashi et al., 2023; El Archi et al., 2023; Saifudin & Widiyaningtyas, 2024; Solano-Barliza et al., 2024; Huda et al., 2024; Piliponyte et al., 2024; Kumar et al., 2024; Flórez et al., 2025). Limited research integrates transparent expert-defined recommendation rules, schedule-availability constraints, mobile rental submission, and operational evaluation within a public tourism venue rental service. Moreover, expert-defined criterion weights are rarely examined against a simple baseline or tested for ranking stability.

This study addresses these gaps by developing a mobile tourism venue rental application integrated with a knowledge-based recommendation system for BLUD UPT Teratai Mas. The recommendation mechanism evaluates activity type, participant capacity, facilities, and location preference, followed by schedule-availability filtering. To strengthen the recommendation evaluation, the expert-weighted model is compared with an equal-weight baseline, while sensitivity analysis examines whether moderate changes in criterion weights alter the resulting venue rankings. The application was developed using Rapid Application Development, Flutter, Laravel REST API, and MySQL. Functional correctness was evaluated through expanded Black Box Testing, while usability and acceptance were assessed through User Acceptance Testing involving a broader user sample. The novelty of this study lies in integrating transparent recommendation rules, mandatory schedule constraints, mobile rental submission, comparative recommendation evaluation, and operational system testing within a public tourism venue management context.

2. Materials and Methods

2.1 Knowledge-Based Recommendation

The proposed system employed a knowledge-based recommendation approach because tourism venue selection depends on explicit user requirements, venue characteristics, and operational constraints rather than historical ratings or previous user interactions. The criteria were identified through requirement analysis and consultation with BLUD UPT Teratai Mas representatives responsible for tourism venue and rental services. Four criteria were used: activity type, participant capacity, required facilities, and location preference (Gamidullaeva et al., 2023; Saifudin & Widiyaningtyas, 2024; Solano-Barliza et al., 2024).

Each criterion was converted into a score ranging from 0 to 1. The complete scoring rules used to calculate SC_1–SC_4 are presented in Table 1.

Based on Table 1, indoor-oriented activities included seminars, meetings, workshops, talk shows, and training activities, whereas outdoor-oriented activities included outbound activities, bazaars, performances, camping, concerts, sports, and festivals. SC_2 provided a proportional score when the venue capacity was lower than the requested number of participants, while SC_3 represented the proportion of requested facilities available at the venue.

Table 1. Scoring rules for the recommendation criteria

Criterion	Scoring rule
Activity type (SC_1)	A score of 1.0 was assigned when the activity orientation matched the venue characteristics. A score of 0.8 was assigned when the venue supported both indoor and outdoor activities. A score of 0.3 was assigned when the activity orientation did not match the venue characteristics.
Participant capacity (SC_2)	A score of 1.0 was assigned when the venue capacity was equal to or greater than the requested number of participants. Otherwise, the score was calculated as venue capacity/requested participants.
Required facilities (SC_3)	The score was calculated as number of matched facilities/number of requested facilities. SC_3 was set to 1.0 when the user did not request a specific facility.
Location preference (SC_4)	A score of 1.0 was assigned when the preferred indoor or outdoor type matched the venue characteristics, whereas a score of 0.0 was assigned when it did not match.

The criterion weights and their operational justification are presented in Table 2.

Table 2. Criterion weights and operational justification

Criterion	Weight	Operational justification
Activity type (SC_1)	0.35	An incompatible indoor or outdoor environment may prevent the activity from being conducted appropriately.
Participant capacity (SC_2)	0.35	Insufficient venue capacity creates operational and safety limitations.
Required facilities (SC_3)	0.10	Partial facility limitations may still be addressed through additional equipment or arrangements.
Location preference (SC_4)	0.20	Location preference affects user suitability but does not replace the main feasibility criteria.
Total	**1.00**	—

Based on Table 2, activity type and participant capacity received the highest weights because they determine the primary feasibility of a venue. Location preference received a moderate weight, while facilities received the lowest weight because unavailable facilities may, in some cases, be provided separately. The final weighted similarity score was calculated using Equation (1).

$$\mathrm{Sim} = (0.35 \times \mathrm{SC}_1) + (0.35 \times \mathrm{SC}_2) + (0.10 \times \mathrm{SC}_3) + (0.20 \times \mathrm{SC}_4) \quad (1)$$

In Equation (1), Sim denotes the overall similarity score, SC_1 represents activity-type compatibility, SC_2 represents participant-capacity compatibility, SC_3 represents facility compatibility, and SC_4 represents location-preference compatibility. The resulting value ranges from 0 to 1 and was converted into a percentage for ranking the tourism venues.

After the similarity scores were calculated, the system applied schedule availability as a mandatory constraint. The requested date was checked against existing event schedules and approved rental submissions. When an overlap was detected for the same venue and date, the venue was marked as unavailable without changing its similarity score. Therefore, the similarity score represented requirement compatibility, whereas the schedule constraint determined whether the venue could proceed to rental submission.

2.2 Baseline Comparison and Sensitivity Analysis

To evaluate whether the expert-defined weights provided an advantage over a simpler weighting strategy, the proposed model was compared with an equal-weight baseline. The baseline similarity score was calculated using Equation (2).

$$\mathrm{Sim}_{\mathrm{EW}} = (0.25 \times \mathrm{SC}_1) + (0.25 \times \mathrm{SC}_2) + (0.25 \times \mathrm{SC}_3) + (0.25 \times \mathrm{SC}_4) \quad (2)$$

In Equation (2), Sim_{ev} represents the equal-weight similarity score. Both models were evaluated using the same user-requirement scenarios, tourism venue data, scoring rules, and schedule constraints. The comparison considered top-one agreement with venue selections validated by BLUD representatives, ranking consistency, and compliance with mandatory schedule constraints.

A one-at-a-time sensitivity analysis was conducted by increasing and decreasing each original criterion weight by 10%. After one weight was changed, the complete weight vector was normalized using Equation (3) so that the total remained equal to 1.00.

$$w_i' = \frac{w_i(1+\delta_i)}{\sum_{j=1}^{4} w_j(1+\delta_j)} \quad (3)$$

In Equation (3), w_i' denotes the normalized sensitivity weight, w_i denotes the original weight, and δ_i represents a change of -0.10 or +0.10. Only one criterion weight was changed in each sensitivity scenario. Ranking stability between the original and modified weights was evaluated using top-one retention and Spearman's rank correlation, as calculated using Equation (4).

$$\rho = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-1)} \quad (4)$$

In Equation (4), ρ denotes Spearman's rank correlation, d_i is the difference between the original and modified rank of venue i, and n is the number of ranked venues. A value approaching 1 indicates that the recommendation ranking remained stable after the weight modification.

2.2 Rapid Application Development

Rapid Application Development was adopted because it supports rapid prototyping, iterative refinement, and continuous stakeholder involvement. The development process consisted of requirements planning, system design, development, and implementation (Bahari & Pramudwiatmoko, 2025). The four RAD stages applied in this study are illustrated in Figure 1.

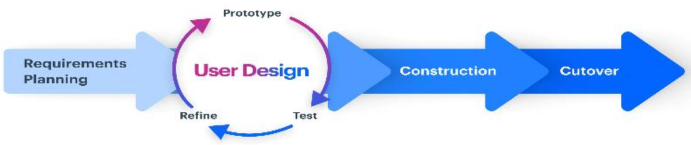

Fig. 1.Rapid Application Development (RAD) Framework

As shown in Figure 1, the requirements-planning phase involved interviews and observations at BLUD UPT Teratai Mas to identify service problems and functional and non-functional requirements. The system-design phase included UML modelling, database design, interface design, and iterative prototype evaluation. The development phase transformed the approved prototype into a functional application using Flutter, Laravel REST API, and MySQL. The implementation phase included system integration, deployment in the testing environment, Black Box Testing, and User Acceptance Testing.

2.3 Mobile Application Development

The tourism venue rental application was developed using Flutter as the cross-platform mobile framework. Laravel was used to implement the RESTful API responsible for authentication, destination information, recommendation processing, rental submission, submission history, schedule management, profile management, and data communication. MySQL stored user accounts, venue characteristics, facilities, schedules, recommendation data, and rental submissions (Al-Atraqchi, 2022).

The system architecture consisted of the Flutter mobile application, Laravel REST API, and MySQL database, as illustrated in Figure 2.

As shown in Figure 2, requests submitted through the Flutter application were transmitted to the Laravel API. The backend validated each request, executed the required business logic, accessed or updated the MySQL database, and returned a structured response to the mobile application. The recommendation mechanism was implemented through the RecommendationService, which received the activity type, number of participants, requested facilities, location preference, and requested date before calculating and returning ranked venue alternatives.

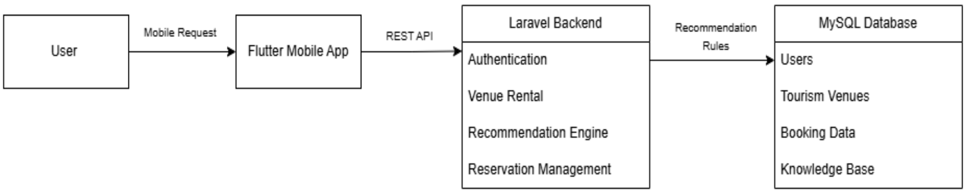

Fig. 2. System Architecture of the Proposed Mobile Tourism Venue Rental Application

2.4 Black Box Testing

Black Box Testing was conducted to evaluate application functionality without examining the internal source code. The test cases were derived from functional requirements, application use cases, interface-validation rules, and the operational rental-service workflow (Romdhana et al., 2022).

The expanded evaluation comprised 152 test scenarios covering login, registration, password recovery, home, tourism destinations, destination details, recommendation, rental submission, submission history, schedule, profile, profile editing, and logout. The scenarios included positive cases, negative cases, boundary-value conditions, incomplete mandatory fields, invalid formats, incorrect credentials, authorization conditions, schedule conflicts, capacity limits, and incomplete supporting documents.

Each test case documented the tested module, precondition, input data, expected output, actual output, test status, and correction notes. A scenario was classified as passed when the actual response corresponded to the expected result. The functional success rate was calculated using Equation (5).

$$\mathrm{BBT} = \frac{N_{\mathrm{passed}}}{N_{\mathrm{total}}} \times 100\backslash\% \tag{5}$$

In Equation (5), BBT denotes the Black Box Testing success rate, N_{passed} represents the number of passed scenarios, and N_{Ntotal} represents the total number of test scenarios.

2.5 User Acceptance Testing

User Acceptance Testing was conducted to evaluate the usability and acceptance of the developed application from the users' perspective. The evaluation involved 65 respondents consisting of BLUD UPT Teratai Mas representatives and prospective users of the tourism venue rental service. Each respondent interacted directly with the main application features before completing the questionnaire.

The questionnaire employed a five-point Likert scale ranging from 1 for strongly disagree to 5 for strongly agree. The evaluation covered five usability aspects: learnability, efficiency, memorability, errors, and satisfaction (Afrianto et al., 2021; Vanesha et al., 2024). The responses were summarized using the mean, standard deviation, and overall acceptance percentage. Questionnaire reliability was evaluated using Cronbach's alpha, with a coefficient of at least 0.70 interpreted as acceptable internal consistency.

The overall UAT percentage was calculated using Equation (6).

$$UAT = \frac{\sum S}{S_{\max}} \times 100\% \tag{6}$$

In Equation (6), UAT denotes the user acceptance percentage, $\sum S$ represents the total actual score obtained from all respondents, and $Smax$ represents the maximum possible score. The maximum score was obtained by multiplying the number of respondents, the number of questionnaire items, and the highest Likert-scale weight.

The percentage interpretation used in the evaluation is presented in Table 3. Based on Table 3, a higher percentage indicates a higher level of acceptance toward the mobile tourism venue rental application.

3. Result and Discussion

This section presents the implementation and evaluation results of the mobile tourism venue rental application integrated with a knowledge-based recommendation system. The discussion covers the mobile application interfaces, recommendation output, comparison with the equal-weight baseline, sensitivity analysis, functional testing, user acceptance, and practical implications for BLUD UPT Teratai Mas. The results are interpreted not only to determine whether the application operates correctly but also to assess whether the proposed approach provides transparent and operationally relevant support for tourism venue selection.

Table 3. User Acceptance Testing interpretation categories

Percentage	Category
0–20%	Very Poor
21–40%	Poor
41–60%	Fair
61–80%	Good
81–100%	Very Good

The application was implemented using Flutter as the mobile framework, Laravel as the REST API backend, and MySQL as the database management system. The recommendation mechanism was implemented in the Laravel RecommendationService, which receives activity type, participant capacity, required facilities, location preference, and requested date from the mobile application. The backend calculates the weighted similarity score, applies schedule-availability filtering, and returns ranked venue alternatives in a structured response. This implementation is consistent with the system architecture and recommendation process described in the research report.

3.1. Mobile Application Implementation

Based on Figure 3 and Figure 4, the developed mobile application provides users with an intuitive interface for accessing tourism venue information and obtaining venue recommendations. The Home interface serves as the main entry point, allowing users to browse available tourism venues and access the application's primary features. Meanwhile, the Recommendation interface implements the knowledge-based recommendation mechanism by matching user requirements with predefined criteria, including activity type, participant capacity, facilities, and location preference. The recommendation results are generated dynamically through the REST API, enabling users to identify suitable tourism venues efficiently before proceeding with the rental process. This implementation demonstrates that the integration of the recommendation module into the mobile application successfully supports user decision-making while improving the efficiency of tourism venue selection.

Based on Figure 5 and Figure 6, the proposed application successfully digitalizes the tourism venue rental process by providing integrated rental submission and schedule management features. The Rental Submission interface enables users to complete reservation requests electronically by entering the required rental information, thereby reducing manual administrative procedures. Furthermore, the Schedule interface presents reservation schedules and venue availability in real time, allowing users to avoid scheduling conflicts before submitting rental requests. The seamless interaction between the mobile application, REST API, and database ensures that submitted rental data are processed efficiently and accurately. These implementation results indicate that the proposed mobile application effectively supports tourism venue rental services while enhancing accessibility, operational efficiency, and user convenience.

3.2 Recommendation Results

The expert-weighted recommendation model calculates venue suitability using the four criterion scores defined in Table 1 and the weighted-similarity function presented in Equation (1). Schedule availability is subsequently applied as a mandatory constraint. A representative output of the recommendation process is presented in Table 4.

Based on Table 4, Convention Hall Putra Sang Fajar obtained the highest similarity score and was available on the requested date. It was therefore placed in the first position and remained eligible for rental submission. Kawasan Indraprana Baturraden was ranked second because its characteristics also corresponded closely to the specified requirements.

Although Bukit Bintang Baturraden obtained a higher similarity score than Taman Botani Baturraden, it was marked as unavailable. This result demonstrates that the final output is not determined solely by the value produced by Equation (1). The schedule constraint prevents a highly compatible venue from being recommended for submission when an approved rental or registered event already occupies the requested date. Taman Botani Baturraden remained eligible because it satisfied the schedule constraint, despite having a lower similarity score.

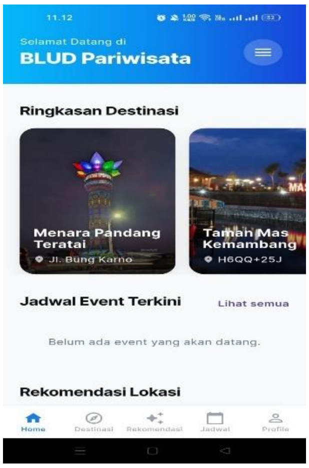

Fig. 3. Home Interface

Fig. 4. Recommendation Interface

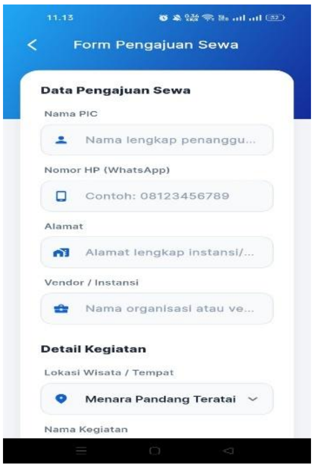

Fig. 5. Rental Submission Interface

Fig. 6. Schedule Interface

Table 4. Representative result of the expert-weighted recommendation model

Rank	Tourism Venue	Similarity Score	Availability	Recommendation Status
1	Convention Hall Putra Sang Fajar	95.0%	Available	Recommended
2	Kawasan Indraprana Baturraden	88.0%	Available	Recommended
3	Bukit Bintang Baturraden	76.0%	Unavailable	Not Recommended
4	Taman Botani Baturraden	69.0%	Available	Recommended

This result illustrates the practical distinction between suitability and availability. Suitability is represented by the weighted score, whereas availability determines whether the recommendation can be acted upon. Combining these two components reduces the possibility that users select a venue that matches their activity requirements but cannot be rented at the intended time.

To address the methodological comparison requested by the reviewer, the expert-weighted model must be compared with the equal-weight baseline defined in Equation (2). The final comparison should be reported using actual evaluation scenarios, as structured in Table 5.

3.3 Black Box Testing Results

Black Box Testing was expanded to cover 152 scenarios derived from functional requirements, interface-validation rules, boundary conditions, authentication conditions, and the operational rental workflow. The overall functional-testing result calculated using Equation (5) is presented in Table 5.

Table 5. User Acceptance Testing Results

Testing Item	Result
Total Test Scenarios	152
Valid	144
Invalid	8
Success Rate	94,74%

Based on Table 5, 144 of the 152 scenarios produced outputs that corresponded to the expected results, resulting in a functional success rate of 94.74%. The expanded test coverage included login, registration, password recovery, home, tourism destinations, destination details, recommendation, rental submission, submission history, schedule, profile, profile editing, and logout.

The result indicates that most of the application functions operated correctly under positive, negative, validation, and boundary-value conditions. The successful scenarios confirm that the Flutter client, Laravel REST API, and MySQL database were generally able to exchange and process data according to the specified functional requirements.

3.4 User Acceptance Testing Results

User Acceptance Testing involved 65 respondents consisting of BLUD UPT Teratai Mas representatives and prospective users of the tourism venue rental service. The respondents evaluated the application after interacting with its principal features. The aggregated result calculated using Equation (6) is presented in Table 6.

Table 6. Summary of User Acceptance Testing Results

Evaluation Item	Result
Respondents	65 respondents
Evaluation Method	User Acceptance Testing (UAT)
Evaluation Aspects	Learnability, Efficiency, Errors, Memorability, Satisfaction
Features Evaluated	Login, Registration, Password Recovery, Home, Tourism Destinations, Recommendation, Rental Submission, Submission History, Schedule, Profile, Edit Profile, Logout
Overall UAT Score	86,2%
Acceptance Category	Very Good (Accepted)

Based on Table 5, the application achieved an overall UAT score of 86.2%. According to the interpretation categories presented in Table 3, this result belongs to the Very Good category. The score indicates that the respondents generally provided positive assessments of the application's ease of learning, operational efficiency, memorability, error handling, and satisfaction.

The evaluation involved a substantially larger respondent sample than the original five-participant assessment. Consequently, the result provides a broader representation of intended users and directly addresses the reviewer's concern regarding the extremely limited original sample. However, the 86.2% value should be interpreted as the aggregate response of the 65 participants rather than as evidence that every potential user will have the same experience.

The difference between the original score of 96.57% and the expanded score of 86.2% is also methodologically reasonable. A larger and more diverse respondent sample generally produces greater variation in perceptions, experience, digital literacy, and expectations. The lower but still highly positive value therefore presents a more conservative assessment of application acceptance.

To strengthen this section further, the final manuscript should also report the mean and standard deviation for each usability aspect and the Cronbach's alpha coefficient calculated from the item-level responses. These values cannot be derived from the overall percentage alone and must be calculated from the 65 completed questionnaires.

4. Conclusion

This study developed a mobile tourism venue rental application integrated with a knowledge-based recommendation system for BLUD UPT Teratai Mas using the Rapid Application Development methodology. The application combines tourism venue information, recommendation, rental submission, submission history, schedule checking, and profile management within a single mobile service. Flutter was used to implement the mobile interface, Laravel REST API handled the application logic and communication services, and MySQL supported structured data storage. This architecture enables users to access venue information and complete rental-related activities through mobile devices while complementing the existing web-based service.

The recommendation mechanism evaluates activity type, participant capacity, required facilities, and location preference using transparent scoring rules and expert-defined weights. Schedule availability is applied separately as a mandatory constraint. This separation enables the system to distinguish venue suitability from operational availability. A venue may therefore receive a high similarity score but remain ineligible for submission when it is unavailable on the requested date. The equal-weight baseline and sensitivity analysis were introduced to improve the methodological evaluation of the expert-weighted model and to examine whether recommendation rankings remain stable under alternative weighting conditions.

The expanded Black Box Testing covered 152 functional scenarios involving positive, negative, boundary-value, validation, authorization, and exception conditions. Based on the revised testing summary, 144 scenarios produced the expected outputs, resulting in a functional success rate of 94.74%. The remaining eight scenarios indicate that further corrective and regression testing is required before full production deployment. User Acceptance Testing involving 65 respondents produced an overall score of 86.2%, which was classified as Very Good. This result indicates positive acceptance among the participating BLUD representatives and prospective users, although it should not be interpreted as universal acceptance across all potential user populations.

The main contribution of this study lies in integrating transparent expert-defined recommendation rules, schedule-availability constraints, mobile rental submission, functional evaluation, and user acceptance assessment within a public tourism venue rental context. The application may reduce manual venue comparison, help users identify schedule conflicts earlier, and support more structured rental administration. Nevertheless, the study remains limited to one organization, a predefined knowledge base, and a simple comparison baseline. Future research should evaluate additional recommendation methods, expand the criteria to include rental cost, accessibility, popularity, and user preferences, and conduct security, performance, scalability, and long-term adoption assessments. Integration with digital payments, maps, notifications, and broader smart-tourism services should also be considered.

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