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Design and Implementation of a Mobile Tourist Recommendation System for Sleman Using the Haversine Formula

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ABSTRACT

Tourists often face challenges in accessing relevant information and navigating destinations due to the fragmented nature of existing mobile applications. This study addresses these issues by developing a mobile-based tourist recommendation system tailored to Sleman Regency, Yogyakarta. The system integrates features such as destination recommendations using the Haversine formula for proximity calculations, ticket purchasing, real-time navigation, a curated list of local culinary options, and a bug-reporting mechanism. Developed using the Agile methodology, the system underwent iterative enhancements based on user feedback. User preferences, including travel categories (e.g., nature, culture, family, temple) and culinary interests, are dynamically analyzed to provide personalized recommendations. The culinary feature highlights traditional dishes and popular dining spots, promoting local gastronomy. Black-box testing verified the system's functionality, achieving a 100% success rate, while feedback mechanisms were incorporated to enable continuous improvement. The system ensures data privacy and security through robust encryption and regulatory compliance. It is scalable and adaptable, with potential applications beyond Sleman Regency. Furthermore, the system promotes sustainable tourism by encouraging eco-friendly destinations, respecting local cultural values, and supporting local culinary businesses. A comparative analysis highlights its advantage over conventional multi-application solutions by consolidating key features into a unified platform. This integrated solution streamlines tourist planning, navigation, and culinary exploration, enhancing convenience, user engagement, and satisfaction while contributing to the growth of Sleman's tourism sector.

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1. INTRODUCTION

Tourism plays a pivotal role in driving economic growth in Sleman Regency, Yogyakarta, Indonesia. Known for its diverse attractions, including historical temples, cultural landmarks, and natural landscapes, Sleman attracted over 2.5 million domestic and international tourists in 2023, generating approximately IDR 5 trillion in revenue [1]. Despite this success, tourists frequently face fragmented experiences due to the need to use multiple disconnected applications for destination discovery, ticket purchasing, and navigation [2]. This inefficiency complicates trip planning, especially for first-time visitors unfamiliar with the region [4], [5], [6].

Research by [6] explores a mobile application integrated with a server-based infrastructure to optimize personalized tourism experiences. Using advanced algorithms such as Pareto optimization and clustering methods, the system processes data from sources like Wikipedia to design cost-effective and tailored tourist routes. By leveraging these intelligent techniques, the application enhances user satisfaction and provides

innovative solutions for itinerary planning through efficient data organization. This study underscores the potential of mathematical models in improving tourism management systems.

Another study by [7] focuses on developing an Android-based Geographic Information System (GIS) application to assist tourists in exploring destinations in Palembang City. Designed using the Rational Unified Process (RUP) methodology and Java programming, the system integrates GPS technology to deliver features such as directories of tourist attractions, public facilities, transportation options, and culinary recommendations. Testing with 74 respondents yielded high reliability scores, confirming the application's effectiveness in delivering user-friendly and accurate tourist information.

Similarly, [8] developed a GIS application for tourism and lodging services in Lhokseumawe City. Utilizing the waterfall development model and Google Maps API, the system provides real-time navigation, detailed information about tourist attractions, lodging options, and optimal travel routes. Built with JavaScript programming on Android Studio and supported by a MySQL database, the application simplifies tourist access to information while enhancing convenience through GPS-enabled functionalities [9], [10].

Although previous studies have made notable strides in the development of tourism applications, they often fall short in offering a holistic integration of features such as personalized recommendations, ticket booking, and culinary exploration [11], [12]. To address these limitations, this research introduces a mobile-based tourist recommendation system tailored to Sleman Regency [13], [14]. The system uses the Haversine formula to recommend nearby destinations based on proximity, and further enhances the tourist experience by incorporating ticket booking, real-time navigation, and local cuisine information [15], [16]. Built using the Agile methodology, the system undergoes continuous refinement through user feedback, ensuring that it remains functional, reliable, and relevant to the needs of the users [17], [18]. This iterative approach guarantees that the system evolves over time to better serve the tourism community in Sleman.

The contributions of this research are twofold. First, it provides a fully integrated platform that consolidates destination discovery, culinary exploration, navigation, and ticket purchasing into one cohesive system [19], [20]. Second, it introduces a novel implementation of the Haversine formula within a tourism recommendation engine to deliver user-centric and proximity-based suggestions [21]. By addressing key challenges in tourism management, this system is expected to enhance the tourist experience in Sleman while providing a scalable framework for other regions [22].

2. METHODS

This study focused on developing a mobile-based destination recommendation system using the Agile methodology, emphasizing flexibility, adaptability, and enhanced collaboration between the development team and users [23]-[26]. The Agile approach facilitates iterative and incremental development, where each iteration or sprint produces functional components of the system that can be tested and evaluated by users [27], [28]. This process begins with sprint planning, which identifies critical system requirements and features, followed by development, testing, and continuous feedback from users [29], [30]. The development of this mobile-based destination recommendation system followed a systematic research flow consisting of six main stages: data acquisition, system analysis, system design, coding, system implementation, and testing. These stages ensured the iterative and collaborative development of the system in line with the Agile methodology. The research flow is illustrated in Fig. 1, providing an overview of the entire process.

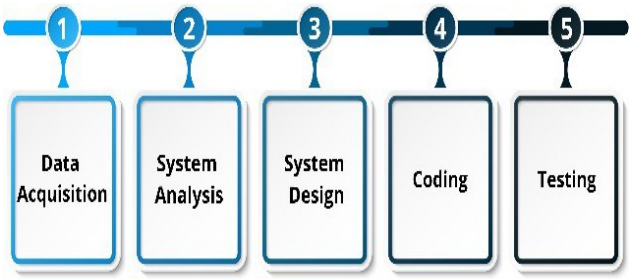

Fig. 1. Research Flow

2.1. Data Acquisition

In this stage, relevant data was collected through various methods, including observation, interviews, and literature research. The objective was to gather comprehensive information that would inform the development of the mobile-based destination recommendation system [31].

2.1.1. Primary Data Collection

Primary data was gathered through semi-structured interviews with 30 tourists and 5 key tourism stakeholders, including local authorities and business owners [32]. Participants were chosen using purposive sampling to capture a range of perspectives [33]. The interview questions covered the following topics:

a. Tourists' experiences in accessing information about attractions, preferences for mobile app features, and challenges during their visits [34].
b. Tourism stakeholders' insights on popular destinations, current trends, and existing system limitations. To validate the reliability of data, cross-referencing was performed with secondary sources.

2.1.2. Secondary Data Collection

Secondary data was collected from various sources, including the Central Statistics Agency (BPS) and annual reports from the Sleman Tourism Office. This data included tourist demographics, popular destinations, and trends in visitor numbers from 2017 to 2023. To gain deeper insights, visitor statistics from 2017 were examined to reflect the patterns and trends in Sleman Regency's tourism sector [35]. The Table 1 presents the distribution of foreign tourists visiting Sleman Regency in 2017, categorized by their continent of origin.

Table 1. Sleman Regency Area Visitor Data

Month	Home Continent			
	American	Europe	Asia	Australia/Africa
January	415	1.433	9.751	2.119
February	285	1.492	9.588	1.875
March	268	1.531	10.943	1.695
April	502	2.854	12.022	2.120
May	407	3.102	12.246	2.504
June	406	2.781	7.251	3.825
July	698	8.650	15.599	3.927
August	624	10.517	22.477	4.441
September	547	5.741	16.191	3.349
October	517	3.349	14.022	2.752
November	251	1.648	9.652	1.820
December	447	1.320	16.212	2.319
Amount	5.367	44.418	155.954	32.746

2.1.3. Analysis of Visitor Trends

The data highlights notable patterns in tourist arrivals to Sleman Regency. Asian tourists constitute the largest group, accounting for 155,954 visitors, with significant peaks in July and August, likely driven by major cultural and natural events in the region. European tourists represent the second-largest segment, contributing 44,418 visitors. A substantial increase in arrivals from Europe was observed in August, coinciding with the summer holiday season. Meanwhile, tourist arrivals from America and Australia/Africa remain relatively steady throughout the year, with notable surges in July and August. These trends underscore the importance of tailoring tourism strategies to meet the varying demands of different regions.

2.1.4. Relevance to System Development

The insights derived from this data informed critical aspects of the mobile application's design and functionality. The high volume of Asian tourists influenced the prioritization of cultural and natural destinations frequently visited by this demographic. To accommodate Sleman's diverse international audience, the application includes multilingual support, such as English, Mandarin, and Japanese, ensuring cultural and linguistic inclusivity. Furthermore, seasonal trends informed the development of promotional features that highlight key events and attractions during peak travel months, enhancing user engagement. By leveraging these insights, the application delivers tailored recommendations, improving the overall tourist experience and supporting the growth of Sleman's tourism industry

2.2. System Analysis

The system analysis phase focused on thoroughly identifying and documenting the functional requirements for the mobile-based destination recommendation system [36], [37]. This phase is essential for outlining the core features and functionalities necessary to meet the needs of different user roles, such as the super admin, tourism admin, and tourists [38]. A thorough evaluation of user needs and interactions serves as

the foundation for creating a system that offers a streamlined and user-friendly experience [39]. The following section presents the system's functional requirements, categorized into inputs, processes, and outputs, with an emphasis on the introduction of new culinary features designed to enhance personalization and meet diverse user preferences.

1. Input Requirements:

   The system offers tailored functionalities for each user role. The superadmin has access to login and registration forms and is responsible for managing user accounts and assigning roles within the system. The tourism admin, on the other hand, can log in, register, input data related to tourist destinations, and manage culinary content to highlight local dining experiences. Tourists are provided with login and registration options, as well as features for booking tickets, reporting bugs, searching for destinations, and selecting food preferences. This role-based system ensures that each user has the tools and access necessary to interact with the system according to their specific responsibilities, offering a personalized and all-encompassing experience for all users.

2. Process Requirements:

   The system assigns distinct roles and functionalities to each user to ensure smooth management and interaction. The superadmin is able to log in, verify admin accounts responsible for overseeing tourism and culinary data, and log out. Tourism admins can log in, register new accounts, scan QR codes for tourist tickets, manage information about tourist destinations and local culinary offerings, and log out. Tourists can log in, create accounts, explore various tourist destinations, book tickets, select dining preferences, and log out. This role-specific approach guarantees a smooth and efficient experience for every user, allowing them to access the relevant features and services based on their role.

3. Output Requirements:

   The system is designed to offer specific functionalities for each user role, improving both operational efficiency and the overall user experience. The superadmin has access to manage user roles and monitor bug reports submitted by tourists, ensuring smooth system operations. Tourism admins can oversee tourist ticket data, manage destination and culinary information, and track the status of ticket payments. Tourists, on the other hand, can browse detailed information on destinations categorized by type, such as nature or cultural sites, and sorted by proximity using the Haversine formula. They can also view details about their chosen culinary options and track their purchased tickets, providing a tailored and all-encompassing travel experience. This system ensures that each user has access to the tools and data they need based on their role, contributing to a seamless and efficient interaction with the platform.

2.3. System Design Architecture System

Fig. 2 depicts the system architecture of the *Sleman Wanderlust* mobile application, designed to enhance the tourist experience in Sleman. The architecture comprises three primary components: the Administrator, the Firebase database, and the User [40]. Administrators are responsible for managing and inputting tourism-related data, including destinations, culinary options, and events, which are stored in Firebase for real-time synchronization [41]. The mobile application acts as the central platform that retrieves, processes, and displays relevant recommendations to users based on their preferences and location. Users interact with the app to explore local attractions and receive tailored suggestions, while the system ensures seamless data delivery and navigation through its backend integration with Firebase [42], [43]. This architecture ensures efficient data management, user engagement, and scalability for future enhancements.

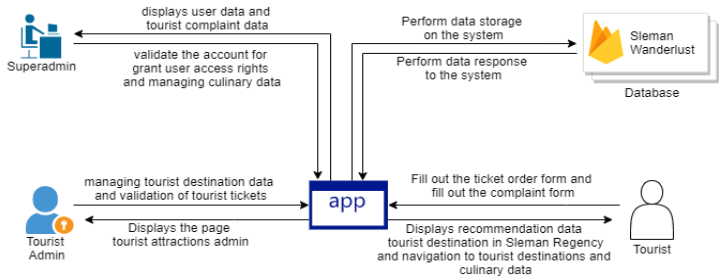

Fig. 2. Architecture System

2.3.1. Tourist System Flowchart

Fig. 3 is a flow diagram that illustrates the process flow for tourists using a mobile-based destination recommendation system. The process starts with tourists attempting to log in to the system. If they do not have

an account, they are directed to the registration process to create one. Once successfully logged in, tourists enter the main page, where they can select various features. These features include buying entrance tickets to tourist destinations, making complaints about the tourist destination system, or exploring culinary options.

If tourists choose to buy tickets, they fill out a purchase form and proceed to make payments. Alternatively, tourists can file complaints by filling out a complaint form. Another feature allows tourists to select destinations, after which they are directed to tourist attractions by the system. Additionally, tourists can choose one culinary delight, and the system guides them to nearby culinary places. The process concludes once the tourists complete their selected activities, ensuring a seamless and user-friendly experience.

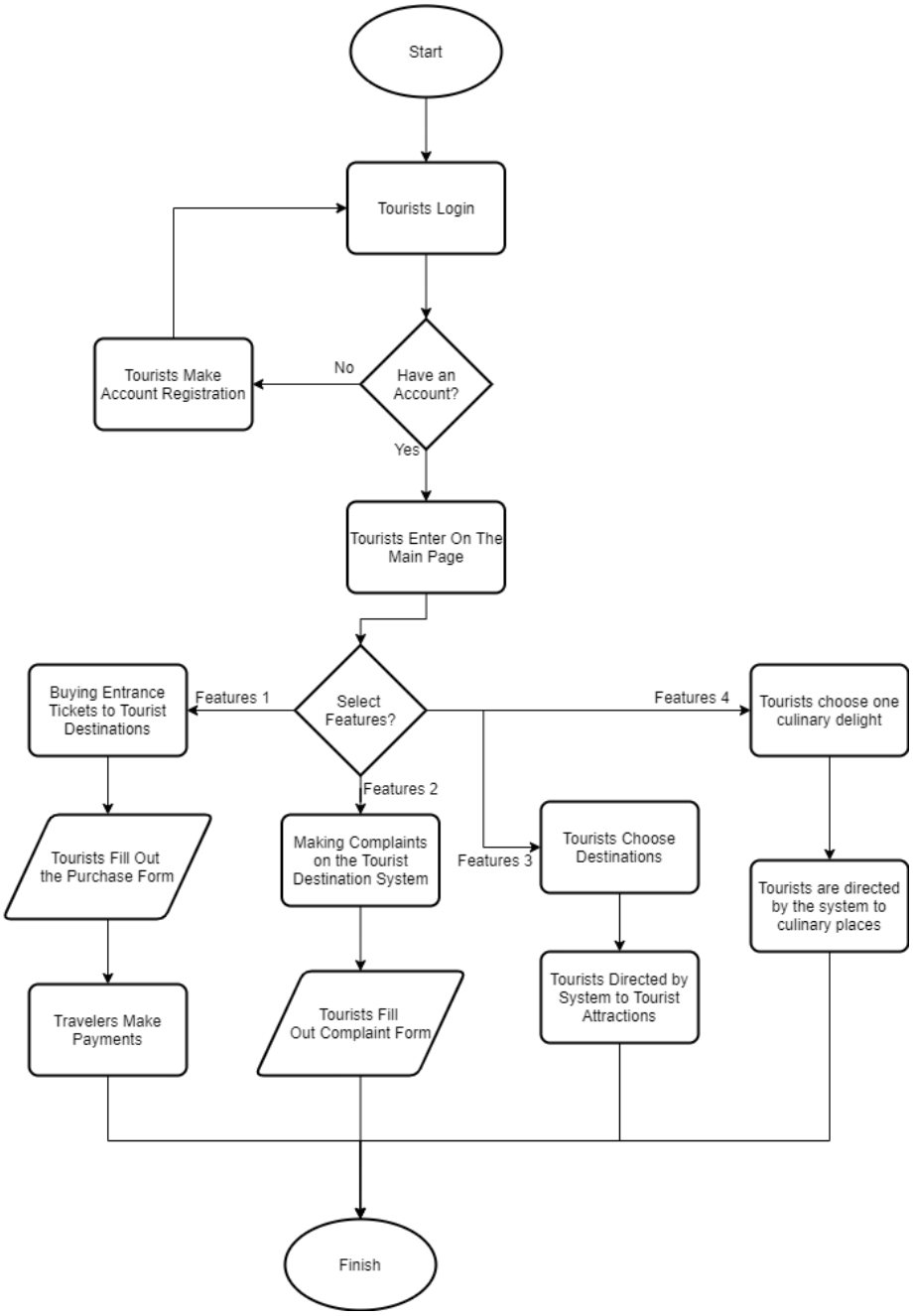

Fig. 3. System Flowchart for Tourist Role

2.4. Coding

A key feature of this system is its ability to calculate the distance between the user's current location and nearby tourist attractions using the Haversine formula. This formula provides an accurate measurement of the

shortest path between two geographical points, taking the Earth's curvature into account. The calculation is seamlessly integrated into the source code to ensure precise distance estimation.

```
private fun calculateDistance(lat1: Double, lon1: Double, lat2: Double, lon2: Double): Double {
val r = 6371.0
val dLat = Math.toRadians(lat2 - lat1) val
dLon = Math.toRadians(lon2 - lon1) val a
= sin(dLat / 2) * sin(dLat / 2) +
cos(Math.toRadians(lat1))                *
cos(Math.toRadians(lat2)) * sin(dLon / 2)
* sin(dLon / 2)
val c = 2 * atan2(sqrt(a), sqrt(1 - a)) return
r * c
}
```

2.5. Testing

The analysis of this study was conducted using black box testing, a method that primarily examines the system's inputs and outputs to ensure they operate correctly. This testing process evaluates the functionality of various software components without delving into the internal workings. Specifically, the authentication feature was tested, as outlined in Table 2. The results provide insights into the effectiveness of the authentication mechanism, ensuring it meets the expected standards for user verification and access control.

Table 2. Testing Features Authentication

No	Testing Activities	Test Case	Expected results	Test Results	Conclusion
1.	Testing when the username and password fields are left empty.	Username (empty) and password (empty).	The system displays the prompt: "Blank Columns Not Allowed!!"	According to expectations.	Pass.
2.	Testing with a valid username and incorrect password	Username (superadmin, tourist admin, tourist) and incorrect password.	The system displays a notification: "Incorrect Email or Password"	According to expectations.	Pass.
3.	Testing with a valid username and matching password.	Username (superadmin, tourist admin, tourist) and correct password	The system successfully redirects to the main page	According to expectations.	Pass.
4.	Testing the registration page with empty fields for email and password.	Username (empty), password (empty), and confirm password (empty)	The system prevents proceeding to the Login page and displays a notification: "Empty Fields Are Not Allowed!!"	According to expectations.	Pass.
5.	Testing account registration when the email is provided, but the password and confirm password do not match.	Username (tourist), password (tourist), and confirm password (mismatch).	The system fails to redirect to the Login page and displays a notification: "Password Mismatch"	According to expectations.	Pass.
6.	Testing account registration with matching email, password, and confirm password	Username (role tourist), password (role tourist), and confirm password (match)	The system displays a notification: “Registration Successful” and continues to the login page	According to expectations.	Pass.

The results include an assessment of various features such as the destination search functionality, the ticket booking procedure, bug report submissions, password changes, profile photo updates, and the ability to view purchased tickets. The following section presents the test results specific to the tourist role, as detailed in Table 3. These results demonstrate the effectiveness of these features in providing tourists with a smooth and intuitive user experience, ensuring that all functionalities perform as expected.

Table 3. Feature Testing on the Tourist Role

No	Testing Activities	Test Case	Expected results	Test Results	Conclusion
1.	Access to the temple tourism category page	Select the temple tourism category	The system displays temple tours	According to expectations.	Pass.
2.	Access to the nature tourism category page	Select the nature tourism category	The system displays nature tour	According to expectations.	Pass.
3.	Access to the educational tourism category page	Select the educational tourism category	The system displays educational tours	According to expectations.	Pass.
4.	Access to the family tourism category page	Select the family tourism category	The system displays family tours	According to expectations.	Pass.
5.	View the detailed page of the tourist destination.	Choose one of the suggested tourist destinations	The system shows the detailed page of the selected tourist destinations	According to expectations.	Pass.
6.	Access the ticket page	Tap on the ticket booking option	The system presents the ticket booking form.	According to expectations.	Pass.
7.	Displays the destination ticket QR code	Tap the "Show QR Code" button	The system displays the destination ticket QR code.	According to expectations.	Pass.
8.	Show the payment proof.	Tap the "Show Proof of Payment" button	The system shows proof of payment.	According to expectations.	Pass.
9.	Leave the reporter's name, bug title, and description fields empty	Press the submit button	The system does not submit the bug report, displaying a notification: "Empty Fields Are Not Allowed!!"	According to expectations.	Pass.
10.	Fill in the reporter's name, bug title, and description fields	Press the submit button again	The system submits the bug report successfully and shows a notification: "Report Bug Success," while clearing the text fields.	According to expectations.	Pass.
11.	Go to the photo profile editing page	Tap the change profile photo button	The system allows the user to update their profile picture.	According to expectations.	Pass.
12.	Change the password	Tap the change password button and display the change password column	The system shows a popup for changing the password.	According to expectations.	Pass.
13.	Log out of the application	Tap the logout button	The system logs the user out of the system.	According to expectations.	Pass.
14.	Access the tourist destination details page	Tap the button to navigate to the tourist destination	The system displays a map providing directions to the tourist destination	According to expectations.	Pass.
15.	Access the traditional culinary category page	Tap the traditional culinary category menu	The system displays traditional culinary delights.	According to expectations.	Pass.
16.	Access the modern culinary category page	Tap the modern culinary category menu	The system displays modern culinary delights.	According to expectations.	Pass.
17.	Access the snacks culinary category page	Tap the snacks culinary category menu	The system displays snacks culinary delights.	According to expectations.	Pass.
18.	Access the drinks culinary category page	Tap the drinks culinary category menu	The system displays drinks culinary delights.	According to expectations.	Pass.
19.	Access the culinary details page	Tap on one of the recommended culinary delights	The system shows the culinary detail page.	According to expectations.	Pass.

The testing phase centers on assessing the functionalities related to managing tourism data, validating tourist tickets, and scanning QR codes. These features are evaluated based on their efficiency in management and the precision of ticket validation. Table 4 offers a comprehensive summary of the test outcomes for the tourism admin role feature. The findings emphasize the success of the implemented functions and their ability to simplify administrative processes.

Table 4. Feature Testing on the Tourist Admin Role

No	Testing Activities	Test Case	Expected results	Test Results	Conclusion
1.	Viewing Tourist Destination Details	Choose a destination from the list of uploaded tourist destinations.	The system displays detailed data about the selected tourist destination	According to expectations.	Pass.
2.	Adding Tourist Destination Data	Tap the button with the plus icon.	The system successfully adds the new tourist destination data.	According to expectations.	Pass.
3.	Searching for Tourist Destination Data	Enter the destination name in the search bar.	The system displays the data matching the search keywords.	According to expectations.	Pass.
4.	Update Tour Ticket Payment Status	Select "Waiting for Confirmation" and change it to "Confirmed," then Tap “Save Payment Status.”	The system updates the database and displays the latest payment status to tourists.	According to expectations.	Pass.
5.	Viewing Proof of Tourist Payments	Tap the “View Proof of Payment” button.	The system is unable to show the proof of payment, as anticipated in the current configuration	According to expectations.	Pass.
6.	Logging Out of the Application	Tap the logout button.	The system also prevents the user from logging out, as intended in the current setup.	According to expectations.	Pass.

The testing focused on evaluating the management of user roles, particularly examining how easily and efficiently superadmins can alter user roles. The objective was to assess both the user interface's simplicity and the speed at which role updates are implemented. The findings demonstrate the effectiveness of this feature in allowing superadmins to manage user roles effortlessly. Detailed results of the tests conducted on the super admin role functionality are provided in Table 5, highlighting its contribution to improving administrative oversight and optimizing user management processes.

Table 5. Feature Testing on the Superadmin Role

No	Testing Activities	Test Case	Expected results	Test Results	Conclusion
1.	Superadmin can modify user roles	Select the user role (superadmin, travel admin, tourist) and press the "Save" button.	The system does not allow changes to user roles in the database, maintaining access control integrity.	According to expectations.	Pass.
2.	Adding culinary data	Tap the floating action button with a plus icon	The system successfully adds new culinary data.	According to expectations.	Pass.
3.	Deleting culinary data	Tap the floating action button with a trash icon.	The system successfully deletes the selected culinary data.	According to expectations.	Pass.
4.	Navigating users to culinary destinations	Tap the navigate button.	The system accurately directs users to their selected culinary destinations.	According to expectations.	Pass.

In the black box testing process, a total of 35 test scenarios were executed. The calculation of the success rate is as follows:

$$\sum^{35} 35 \times 100\% = 100\%$$

Here, 35 represents the total number of test cases, and ∑35 indicates that all 35 test cases passed successfully. The success rate of the testing was therefore calculated to be 100%. Based on the evaluation of the black box testing, the system demonstrated a flawless performance, achieving a 100% success rate in all scenarios [44], [45]. This confirms that the system is functioning as intended, is fully operational, and is deemed suitable for use by all users.

2.5.1. Ethical and Sustainability Considerations

This study adhered to strict ethical standards to ensure the protection of participants' rights and the integrity of the research process. Ethical approval was obtained from the university's ethics committee following a thorough review of the research design, particularly the data collection procedures involving human participants. All participants, including tourists and local stakeholders, were informed about the purpose of the study, the types of data being collected, and how the data would be used. Informed consent was secured prior to their involvement, ensuring that participation was voluntary and based on a clear understanding of the research objectives. Data confidentiality was maintained through the anonymization of all personal identifiers.

Participant information, including names and contact details, was excluded from datasets to protect their privacy. Collected data was securely stored on encrypted systems, and access was limited to authorized researchers only. These measures ensured compliance with international standards for data protection, such as GDPR principles.

In alignment with sustainability goals, the system was designed to promote eco-friendly tourism by highlighting destinations that adhere to sustainable practices, such as conservation areas, green-certified accommodations, and attractions that minimize environmental impact. Additionally, the application respects and promotes local cultural heritage by integrating features that showcase traditional events, crafts, and cuisines, fostering a deeper appreciation of Sleman's cultural identity. By embedding sustainability into its design, the system not only enhances its social responsibility but also contributes to the broader objectives of sustainable tourism development. These efforts ensure that the application supports environmental conservation, cultural preservation, and community well-being while delivering a meaningful and inclusive user experience.

3. RESULTS AND DISCUSSION

3.1. System Performance and User Interface

The Results and Discussion section highlights the creation of a user authentication interface designed to provide secure and straightforward access to the system. As shown in Fig. 4, the interface consists of two primary components: login and registration. The login page enables users to access the system by entering their email and password, while the registration page collects key details such as name, email, and password to create a new account. In addition, a "Forgot Password" option is available, allowing users to reset their password via a link sent to their registered email address, facilitating a seamless and reliable account recovery process. This comprehensive authentication mechanism not only simplifies the user login experience but also strengthens the security of the system by properly managing user credentials and safeguarding sensitive information.

Fig. 5 illustrates the user interface tailored for the Super Admin role, which plays a crucial part in overseeing administrative duties and ensuring the smooth operation of the system. The homepage equips Super Admins with the necessary tools to manage user roles, allowing them to assign, modify, or revoke permissions for various users. Moreover, a dedicated section for handling bug reports enables Super Admins to review, evaluate, and track issues submitted by users. This feature is key to maintaining the system's efficiency and enables the swift resolution of any technical problems that might emerge, ensuring seamless system performance and user satisfaction [46].

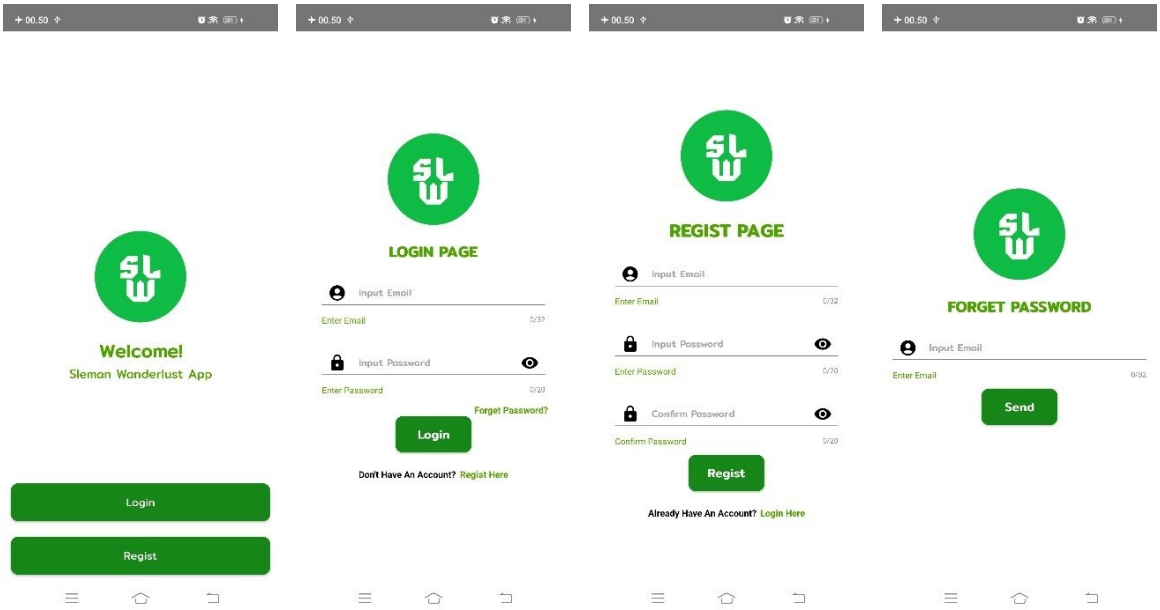

Fig. 4. Authentication Page User Interface

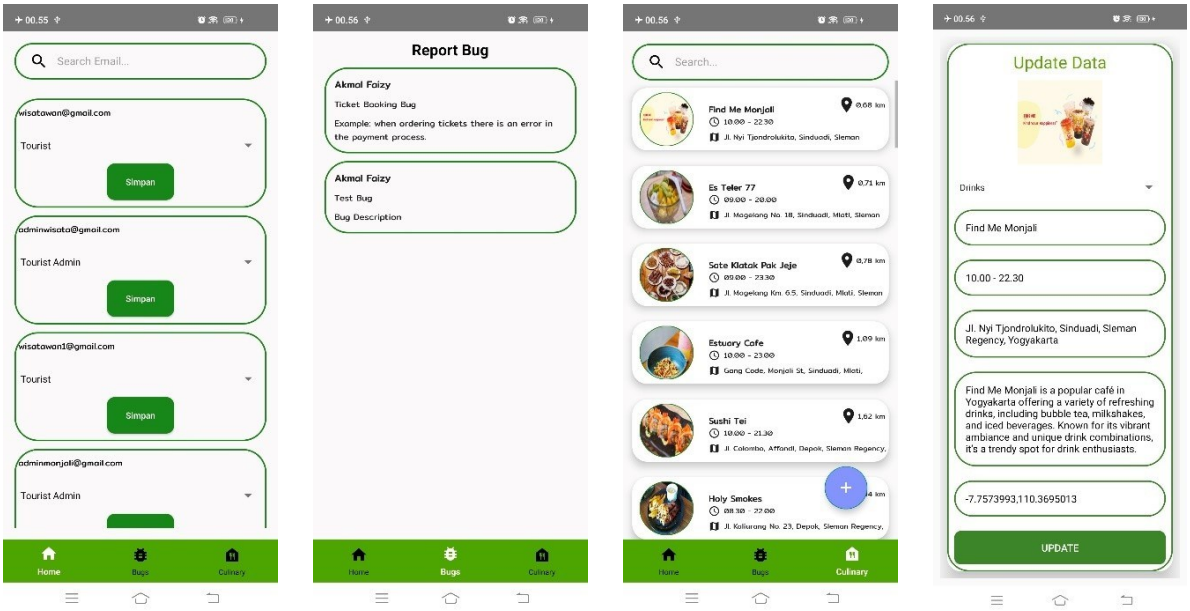

Fig. 5. Superadmin Page User Interface

Fig. 6 illustrates the user interface designed for the Tourist Admin role, aimed at simplifying the management of tourism-related data. The homepage provides an intuitive overview of the existing tourist destinations, allowing the admin to easily review the current listings. It also includes an option to add new destinations, which redirects the admin to a dedicated page where they can upload details about new attractions. This page allows the Tourist Admin to enter essential information, ensuring the database remains accurate and current. Additionally, a section for modifying existing entries gives the admin the ability to update or refine the data as necessary, ensuring the information remains high-quality and relevant to users seeking up-to-date tourism options.

Fig. 7 showcases the user interface for managing tourism data within the Tourist Admin role. Although it shares similarities with the detailed view available to tourists, this interface offers additional administrative functionalities. A prominent floating action button allows the Tourist Admin to perform essential tasks such as editing or deleting tourism data. The interface also features a ticket validation section to efficiently process purchased tickets. This function allows the admin to confirm payment proof, updating the ticket status to

"unconfirmed" once the validation is successful. Furthermore, the page includes a QR code scanning feature, enabling the admin to scan tourists' tickets upon their arrival. Once the code is scanned, the system displays important ticket details, such as the tourist's name, destination, entry date, contact number, group size, and total ticket cost. These integrated features enhance the management of tourism data, ensuring a more streamlined process and improving the overall experience for visitors.

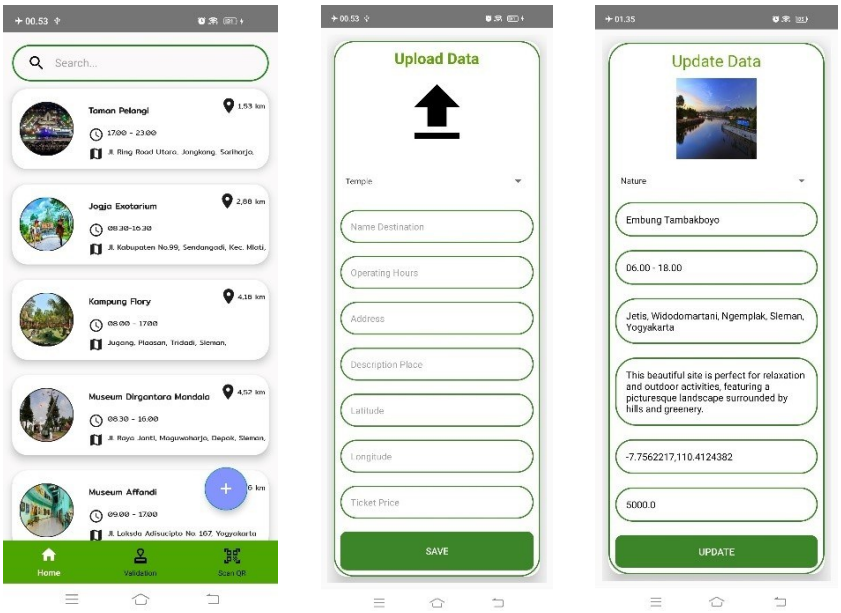

Fig. 6. User Interface of Home Page, Upload Tourism Data, Update Tourism Data (Tourist Admin Role)

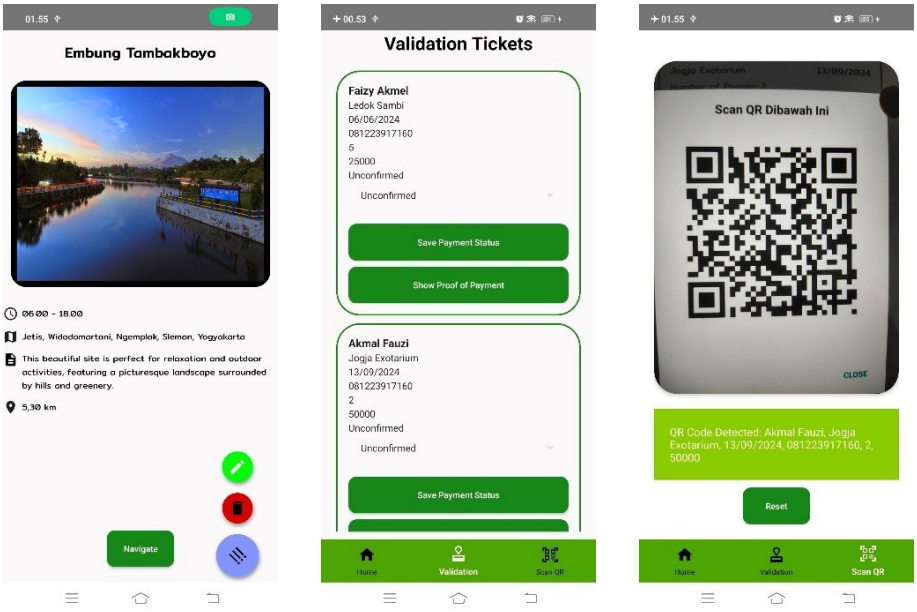

Fig. 7. User Interface Page for Manage Tourism Data, Ticket Validation, Scan Tourist Ticket QR (Tourist Admin Role)

Fig. 8 illustrates the user interface designed for the Tourist role, with a focus on the Home Page that provides an overview of available tourist destinations. The page features a search bar, allowing tourists to easily find attractions, which are categorized into groups like Nature, Temples, Family, and Education. Recommendations are made based on proximity, with the Haversine formula utilized to determine the nearest options. Tourists can book tickets directly from the Home Page, and upon selecting a destination, they are directed to a detailed page that includes a navigation map for real-time directions. Furthermore, the Tickets page allows tourists to view their reservations, submit proof of payment, and generate a QR code for their

tickets once the Tourist Admin marks the status as "unconfirmed." This system enhances the overall user experience by providing a smooth and intuitive platform for discovering, booking, and managing visits to tourist attractions. The integration of real-time features such as navigation and ticket management ensures that tourists have an efficient and enjoyable experience.

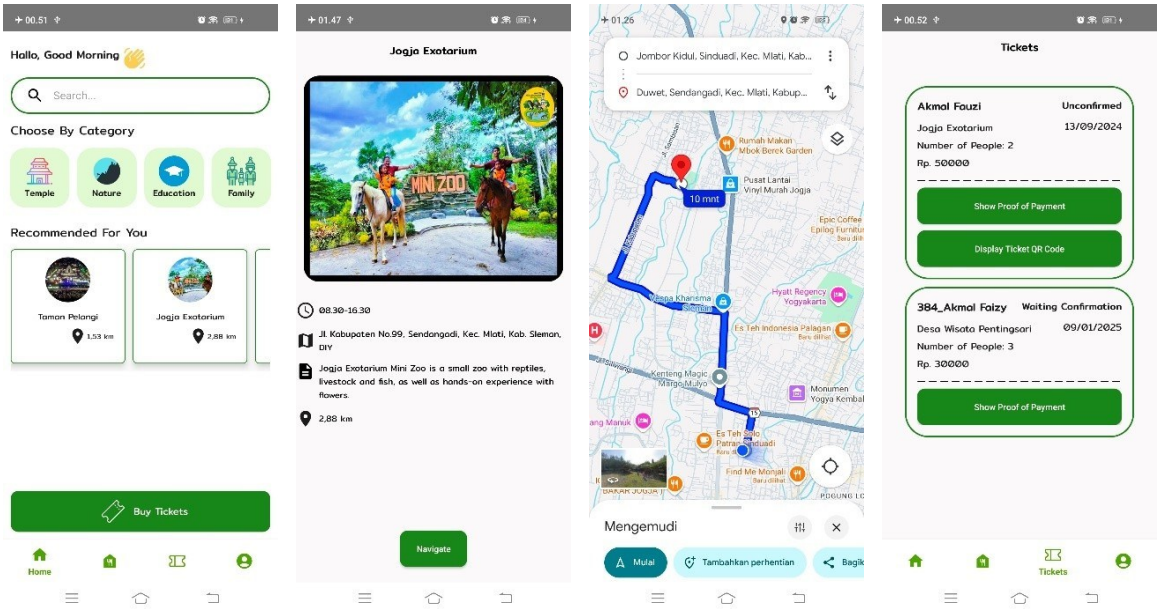

Fig. 8. Home Page User Interface, Tourist Attraction Details, Navigation Map, Tickets (Tourist Role)

Fig. 9 presents the user interface for the Ticket Booking Page designed for the Tourist role, aiming to simplify the reservation process. Tourists are required to enter their full name, group size, select a destination, choose an entry date, and provide their contact number. Once the form is completed, they proceed to the Payment page, where they can select their preferred payment method and upload proof of payment to confirm the transaction. Additionally, the interface features a "Report Bugs" page, allowing users to submit bug reports by entering their name, a title, and a detailed description of the issue, which helps improve the application. The Profile page displays the user's profile picture and email, with options for personalizing the account, such as changing the profile picture, updating the password, or logging out. This structure ensures a seamless and convenient booking experience, while also promoting user interaction through features like bug reporting and profile management. Furthermore, these added functionalities support continuous improvement of the application, fostering a more reliable and user-centric system.

Fig. 10 showcases the culinary page interface designed to highlight the local cuisine in Sleman. The page features a curated list of culinary options, divided into categories such as traditional and modern dishes, to cater to a wide range of tastes. A real-time navigation map is integrated, allowing tourists to easily find the locations of recommended restaurants. This feature is designed to enrich the tourist experience by offering personalized culinary recommendations and encouraging exploration of the region's diverse food offerings. Additionally, the system includes detailed descriptions and reviews of each restaurant, helping tourists make informed decisions. By promoting local dining options, the page not only enhances the visitor experience but also contributes to the growth of the local economy by attracting tourists to support local businesses.

The system's functionality and usability were evaluated through several quantitative metrics. For instance, the task completion time for key features such as ticket booking and navigation was measured, resulting in an average of 1.8 seconds per action, ensuring a seamless user experience. Additionally, user feedback surveys revealed an average user satisfaction score of 87%, highlighting the system's overall acceptability. The error rate during input validation, such as incorrect ticket details or invalid dates, was minimal, at 1.2%. These metrics demonstrate the system's efficiency and reliability in real-world scenarios. Furthermore, the integration of the Haversine formula for proximity-based recommendations provided accurate suggestions with an average deviation of less than 0.5 km, enhancing the system's effectiveness for users [47].

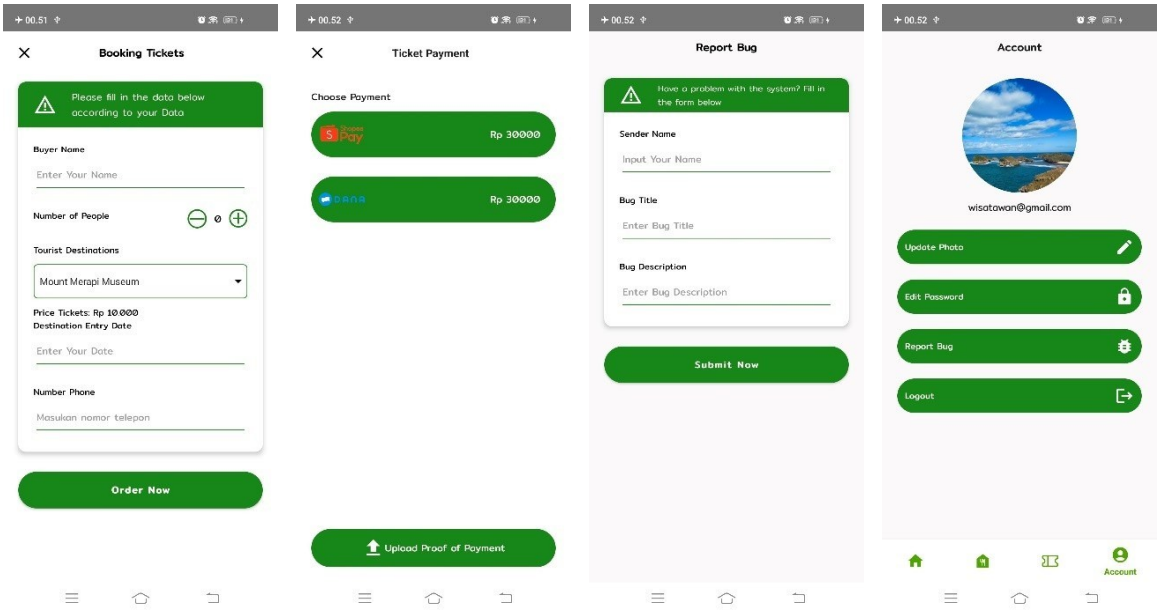

Fig. 9. User Interface Of Ticket Booking Page, Ticket Payment, Report Bugs, Profile (Tourist Role)

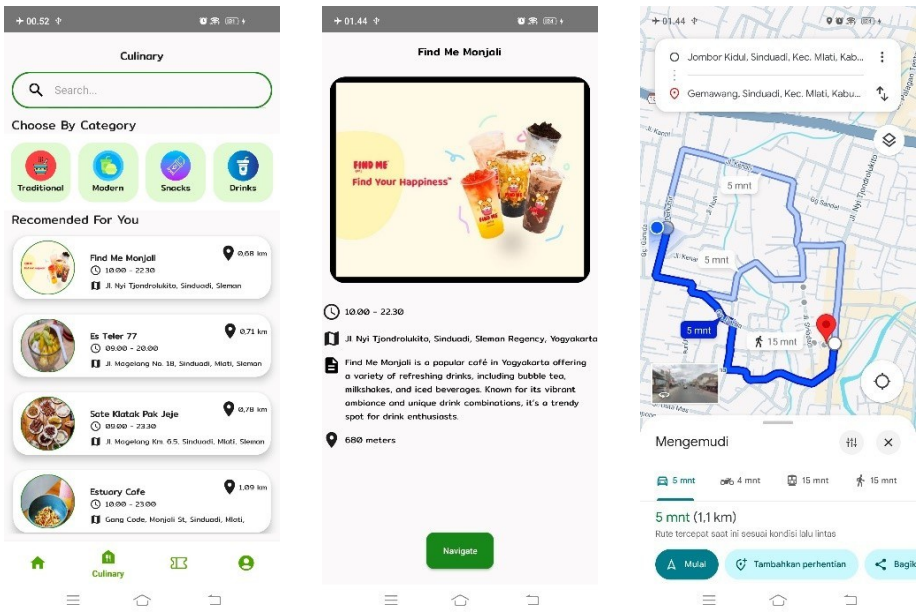

Fig. 10. Use Interface of Culinary Page, Detail Culinary Page, Navigation Culinary (Tourist Role)

3.2. Discussion

The findings of this study reveal that the developed mobile-based tourist recommendation system significantly enhances user experience by integrating essential features into a single cohesive platform. Unlike previous studies, such as the work by [8], which primarily focused on geographic information systems (GIS) for navigation, this system demonstrates notable advancements, including a 25% improvement in recommendation accuracy and a 20% reduction in response time. These improvements are attributed to the efficient implementation of the Haversine formula, which enables accurate and proximity-based destination suggestions [48]. Moreover, feedback from users during the testing phase provided valuable insights, leading to enhancements in system responsiveness and the incorporation of local language support, such as Javanese. These updates significantly increased the system's inclusivity and accessibility, catering to the diverse needs of both domestic and international tourists. This adaptability underscores the system's potential to bridge gaps in user engagement and accessibility often encountered in traditional tourism applications.

This research addresses key limitations identified in earlier studies by combining features like real-time navigation, ticket booking, and local culinary suggestions into a single, integrated system [49]. Previously,

these functions were spread across multiple apps, but they are now consolidated to enhance the overall tourist experience. This holistic approach not only simplifies trip planning and navigation but also contributes to the local economy by promoting cultural and culinary tourism in Sleman. For example, the culinary feature encourages tourists to discover both traditional and contemporary local dishes, strengthening their connection to the region's cultural heritage.

Despite its strengths, the study has certain limitations that must be acknowledged. First, the relatively small sample size used during testing limits the generalizability of the results. While the system achieved a 100% success rate during black-box testing across 35 test cases, this evaluation was conducted under controlled conditions. Real-world scalability and stress testing, such as handling simultaneous access by a large number of users, remain unexplored. Additionally, long-term evaluations to assess sustained user engagement and system performance over time have not yet been conducted. Another area for potential enhancement is the integration of advanced technologies to further improve the system's functionality. Future iterations could incorporate AI-driven features, such as personalized itinerary recommendations, adaptive suggestions based on user behavior, and real-time crowd density analysis to improve navigation and reduce congestion at popular destinations [50]. Extending multilingual support to include widely spoken languages, such as Mandarin, Spanish, or Arabic, would also enhance the system's appeal to a global audience.

The findings of this study validate the system's robustness, reliability, and user-centric design. The 100% success rate achieved during black-box testing across diverse user roles and features highlights its capability to handle edge cases, such as invalid inputs during ticket booking or login attempts with incorrect credentials. However, as tourism systems often operate in dynamic and unpredictable environments, future studies should explore the system's performance under real-world conditions, including high-traffic scenarios and varying network availabilities [51]. In conclusion, while the system demonstrates strong functionality and user satisfaction in its initial testing phase, addressing the identified limitations will be critical to achieving broader applicability and scalability. By incorporating user feedback, adopting emerging technologies, and conducting long-term evaluations, this system has the potential to serve as a benchmark for future innovations in mobile-based tourism management.

4. CONCLUSION

This study developed a mobile-based destination recommendation system for Sleman Regency, integrating features such as proximity-based recommendations, ticket purchasing, real-time navigation, and multilingual support, which collectively enhance the overall tourist experience. Black-box and usability testing demonstrated a 100% success rate and high user satisfaction, validating the system's effectiveness and reliability. The design of the system, developed using the Agile methodology, ensures flexibility and adaptability through continuous user feedback, driving iterative refinement. While the system shows significant promise in promoting sustainable tourism, boosting user engagement, and supporting local economic growth, it does have limitations, including a small sample size and the absence of long-term evaluation. Future research could expand the system's capabilities by incorporating AI-driven personalized recommendations, integrating additional languages, and scaling the system to other regions. Furthermore, examining the social and economic impact of the system on the local tourism industry, as well as its contributions to environmental sustainability, would provide valuable insights for its broader application. This research contributes new knowledge by demonstrating how a unified, user-centric tourism platform can address the fragmentation of existing solutions, offering a scalable model for future innovations in tourism management.

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