A Sustainable Next-Generation Digital Tourism Guide for Sindh Using a Multilingual Chatbot

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In Pakistan, the Sindh tourism sector has great cultural and economic potential, which is still limited due to a lack of digital access, poor navigation facilities, and language barriers. This research paper is an investigation of "A Tech Driven Guide to Explore Sindh", a smart tourism platform that combines Artificial Intelligence, Web-Based Geographic Information Systems, and Progressive Web Application technology to enhance accessibility, usability, and interaction with the culture. The site talks of significant heritage and natural places such as Mohenjo-Daro, Ranikot Fort, and Keenjhar Lake, in addition to offering personalized suggestions and multilingual services. The frontend version of the system is created in React.js and TypeScript, and the backend version is implemented with Node.js and Express.js, as well as MongoDB for data storage. A rule-based recommendation engine was used to analyze user preferences to create a personalized itinerary. The Web GIS module provides interactive spatial visualization and navigation, and PWA enables offline support and cross-device compatibility. The natural language processing-driven chatbot achieved an accuracy of 92 percent during testing across different travel scenarios. A total of 150 survey respondents participated in the evaluation of tourist challenges and system usability. The usability testing results indicated overall satisfaction levels ranging from 82 percent to 90 percent across major system features, with offline access receiving the highest satisfaction score of 90 percent. The extensive testing— including unit, integration, functional, non-functional, black-box, white-box, and performance tests— was used to ensure reliability and usability of the system. The results reveal that the platform enhances access to information, route planning, and interaction with cultural heritage. The system is in line with the Sustainable Development Goals of economic growth, innovation, and sustainable cities. The platform facilitates heritage conservation, community-based tourism, and enhanced visitor satisfaction by integrating modern technology with cultural preservation.

Keywords: Smart Tourism, Artificial Intelligence, Web GIS, Progressive Web Application, Cultural Heritage.

Introduction:

Tourism is a significant contributor to the world economy, job creation, and cultural maintenance [1]. Tourism in Pakistan helps in the development of the region and the diversification of the economy. Sindh is very culturally and historically significant and hosts some of the biggest heritage sites like Mohenjo-Daro, Ranikot Fort, Shah Jahan Mosque, Keenjhar Lake, and Sufi shrines such as [2]. However, the tourism industry in Sindh is not well developed because of the lack of access to trustworthy information, ineffective digital access, language barriers, and a lack of proper navigation tools [3].

The use of AI, Web GIS, augmented reality, and progressive web applications are examples of smart tourism technologies used to facilitate better decision-making and visitor interaction and is now at the center of contemporary tourism systems [4][5]. Nevertheless, Sindh does not have integrated digital services that offer personalization, spatial intelligence, offline functionality, and multilingual features. Current tourism technologies are usually based on static content that is not very interactive or culturally engaging.

Although smart tourism platforms have been implemented in different global contexts, most existing systems focus on either recommendation services, mapping solutions, or general informational portals independently. There is limited evidence of an integrated platform specifically designed for Sindh that combines personalized itinerary generation, spatial intelligence, offline accessibility, and multilingual interaction within a single cohesive framework. Furthermore, existing tourism portals in Pakistan lack structured AI-driven personalization and context-aware guidance tailored to regional cultural heritage. This represents a technical and implementation gap in the digital tourism ecosystem of Sindh.

Here, the authors introduce one smart tourism platform adapted to Sindh that includes the combination of AI-based recommendations, GIS maps, a multilingual interface, and PWA. The site helps users explore culture, navigate, and tailor personal planning in urban and remote locations. The strategy equates technological advancement to cultural sensitivity and facilitates the sustainable growth of the Sindh tourism ecosystem.

Novelty Statement:

This paper introduces a cohesive smart tourism platform for Sindh that combines an artificial intelligence-based recommendation system, web-based geographic information maps, offline capabilities of a progressive web application, and multilingual support. Unlike existing standalone tourism portals, the proposed system integrates personalized recommendations, spatial navigation, and multilingual interaction within a unified architecture tailored to the socio-cultural and infrastructural context of Sindh.

Problem Statement:

Sindh possesses tremendous cultural, historical, and natural attractions, yet there are significant challenges, including a lack of information, ineffective navigation, limited tourist engagement, and language barriers. Such problems decrease interaction and restrict both economic and cultural opportunities of the area. The lack of proper infrastructure, low transportation networks, and the absence of a common tourism portal limit visitor accessibility. This has led to several heritage sites being underutilized, and the tourism sector in Sindh has not been performing well relative to its potential.

Despite the availability of digital tourism technologies globally, there is no integrated smart tourism system in Sindh that combines personalized recommendations, spatial navigation, multilingual support, and offline accessibility within a unified platform. This technical and implementation gap reduces the effectiveness of tourism management and visitor experience in the region.

Aim and Objectives: To create an intelligent tourism application that enhances the touring experience in Sindh by providing personalized recommendations, GIS-based navigation,

multilingual interaction, and offline accessibility while improving overall usability and visitor satisfaction.

To conduct a structured survey of tourists (n = 150) and analyze key challenges related to information access, route planning, personalization, and language barriers.

To design and develop a web-based smart tourism application using React.js, Node.js, and MongoDB with integrated Web-GIS and Progressive Web Application features.

To implement a rule-based recommendation system that achieves high recommendation accuracy (above 85 percent) across different travel scenarios.

To evaluate system usability and performance through functional and non-functional testing, targeting user satisfaction levels above 80 percent across major features.

To ensure multilingual support and offline accessibility to improve user engagement in both urban and remote areas of Sindh.

Literature Review:

Tourism stands out as one of the largest contributors to the economies and cultures of the world. Before the COVID-19 outbreak, the global tourist arrivals amounted to 1.5 billion and created more than USD 1.7 trillion globally, according to the United Nations World Tourism Organization [1]. The pandemic has aggravated the situation, pushing the shift to digital tools to satisfy new customer demands. Artificial Intelligence (AI), Web-based Geographic Information Systems (Web-GIS), and Progressive Web Apps (PWA) are the technologies that now take center stage in smart tourism to assist personalization, navigation, and accessibility. These technologies are particularly relevant to regions such as Sindh, Pakistan, where cultural heritage is rich but digital representation and infrastructure are limited.

AI boosts tourism with automated suggestions, chatbots, and predictive software. Analysis of user preferences, search trends, and other contextual data through machine learning models can provide destination recommendations and generate individual itineraries [6][7]. NLP can enable chatbots to respond in real-time and offer multilingual services at heritage sites, while predictive analytics helps managers monitor visitor traffic and allocate resources effectively [8]. Although advantageous, AI usage in Sindh is limited by the lack of structured datasets, privacy concerns, cultural sensitivity challenges, and poor digital infrastructure [4]. Moreover, many existing AI-driven tourism systems focus primarily on recommendation accuracy but do not integrate spatial intelligence or offline accessibility within a unified framework.

Web-GIS empowers tourism navigation and planning through interactive maps, route planning, and the spatial context of heritage sites. Previous research demonstrates that GIS can significantly aid visitor orientation at cultural sites by providing layered data, including routes, accessibility, and historical information [9]. AR integrations also improve tourism engagement by overlaying historical reconstructions on physical sites [10][11]. Nevertheless, poor connectivity, outdated spatial data, high maintenance costs, and limited technical expertise restrict Web-GIS implementation in developing regions such as Sindh [12]. Many Web-GIS applications operate independently without integration with intelligent recommendation mechanisms.

PWAs offer a viable solution for providing tourism information in locations with unstable network connectivity. They combine the wide availability of web platforms with offline functionality using cached data [13]. PWAs consume less data, have no installation limitations, and are compatible across devices, making them suitable for remote archaeological sites and rural areas. However, PWAs are often implemented as lightweight content delivery tools rather than as components of integrated intelligent tourism ecosystems [14].

Globally, integrating AI, Web-GIS, and PWAs has demonstrated high potential to enhance cultural heritage tourism by providing personalized routes, location-based context, and seamless access to critical information [13]. However, most existing implementations

address these technologies separately rather than as a cohesive architecture tailored to regional socio-cultural conditions. In the context of Pakistan, current tourism platforms remain largely informational and static, lacking structured personalization, multilingual conversational assistance, and offline-enabled spatial interaction. This indicates a clear research and implementation gap in developing an integrated smart tourism system specifically adapted to the infrastructural and cultural context of Sindh.

Methodology:

A structured methodology was used to design and develop smart tourism applications. The methodology consisted of survey-based problem identification, requirement analysis, system design, implementation, and evaluation phases.

Survey and Data Collection:

Primary data were gathered using structured questionnaires to determine tourist issues concerning navigation, accessibility, personalized travel planning, and language barriers. A total of 150 respondents participated in the survey. The sampling approach was convenience-based, targeting tourists and local visitors familiar with travel within Sindh.

The questionnaire consisted of closed-ended questions designed to measure common travel challenges and system expectations. The data collected were tabulated and analyzed using percentage-based statistical analysis to identify dominant problem areas.

Secondary data about heritage sites and cultural content were gathered using UNESCO reports, government data, and relevant literature to ensure the authenticity and reliability of tourism-related information integrated into the system.

Requirement Analysis:

System requirements were divided into functional and non-functional requirements.

Functional requirements included customized advisory services, AI-based itinerary suggestions, GIS-based mapping and navigation, multilingual chatbot interaction, booking management, and offline accessibility through PWA features.

Non-functional requirements included usability, performance efficiency, system reliability, cross-device compatibility, and responsiveness. The usability evaluation focused on user satisfaction levels across major system features, while performance testing ensured stable functionality during different operational scenarios.

System Design and Architecture:

The system design included four main modules:

User Interface Module: Created using React.js and TypeScript to provide an interactive and responsive frontend.

AI Recommendation Engine: A rule-based system designed to analyze user-selected preferences such as travel type, budget range, and interest category to generate personalized itinerary suggestions.

GIS Mapping Module: Responsible for spatial visualization, route planning, and location-based navigation support.

Progressive Web Application (PWA) Module: Implemented to enable offline usage, caching of essential data, and cross-device compatibility for users in low-connectivity regions.

The proposed system follows a five-layer architecture: User Layer, Presentation Layer, Application Layer, Intelligence Layer, and Data Layer.

The Presentation Layer is developed using React.js and TypeScript with PWA support, providing a multilingual interface, chatbot interaction, Web-GIS visualization, and offline functionality.

The Application Layer is implemented using Node.js and Express.js as a REST API server handling authentication, request processing, and communication between frontend and backend modules.

The Intelligence Layer includes a rule-based recommendation engine, an NLP chatbot module, and a GIS integration module for personalized itinerary generation, query handling, and spatial navigation.

The Data Layer utilizes MongoDB to store user records, destination data, booking information, and preference history.

This layered structure ensures modularity, scalability, and efficient data flow across system components.

The recommendation process begins with user travel preferences such as interests, budget, and visit duration.

These inputs are processed through predefined logical rules within the rule-based engine. The system performs category and interest matching using stored tourism data and filters relevant destinations.

Based on rule mapping, a personalized itinerary is generated and returned to the frontend interface.

This deterministic approach ensures computational efficiency, transparency, and consistent recommendation performance.

Workflow Use Case Diagram:

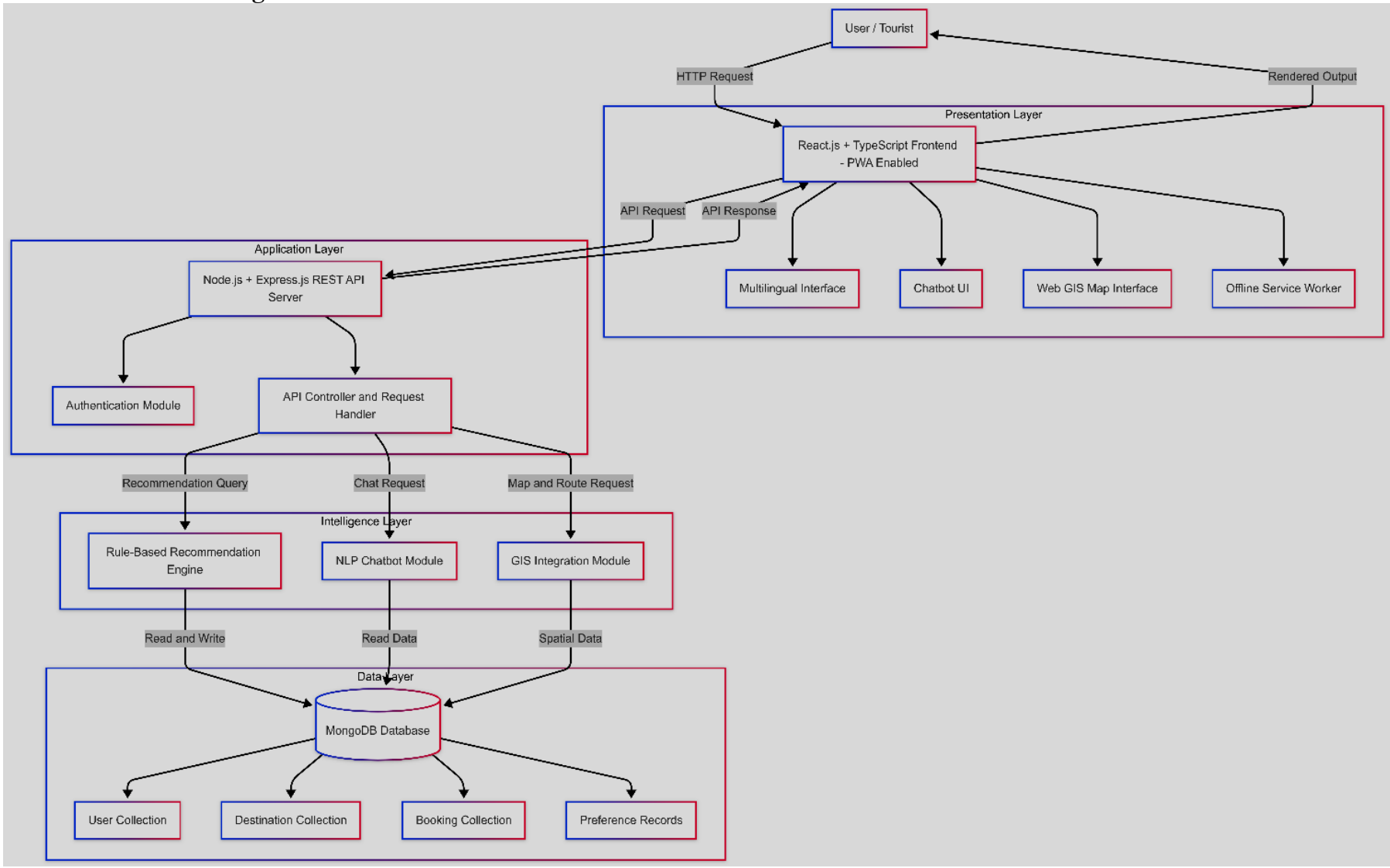

Figure 1. System Architecture

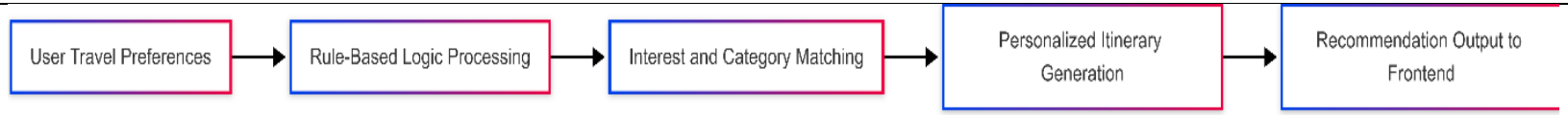

Figure 2. Rule-Based Recommendation Workflow

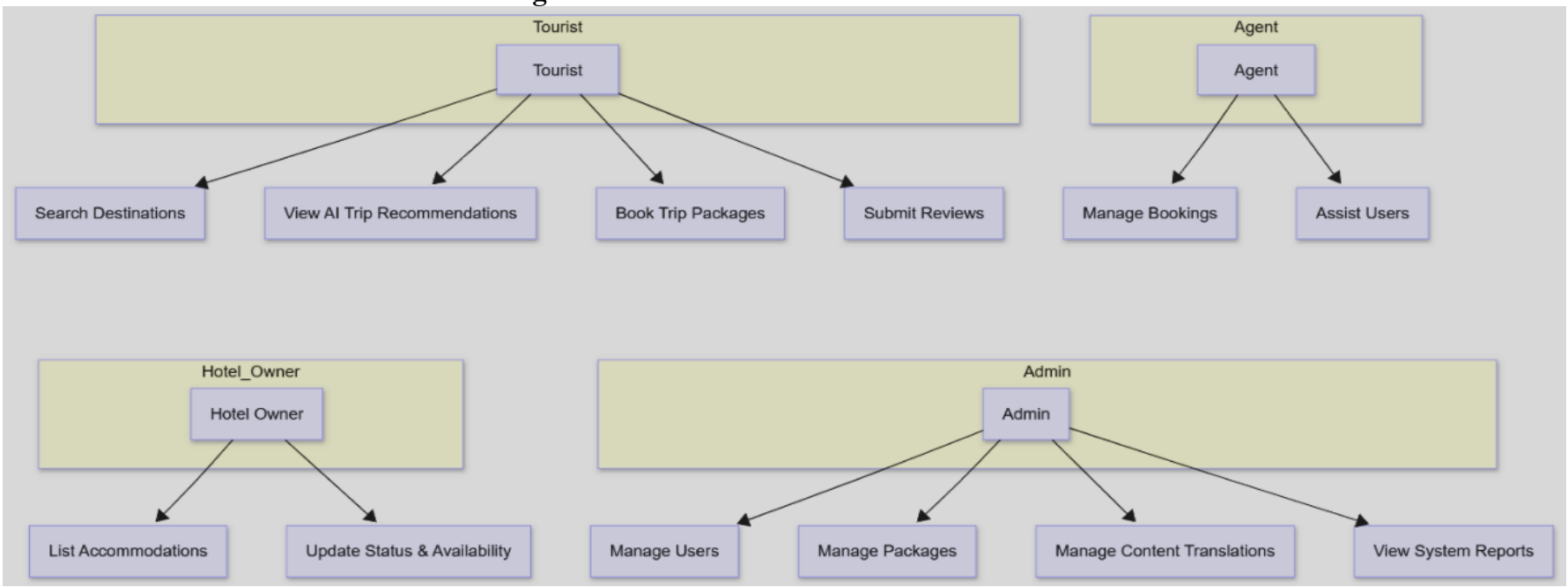

Figure 3. Use Case Diagram

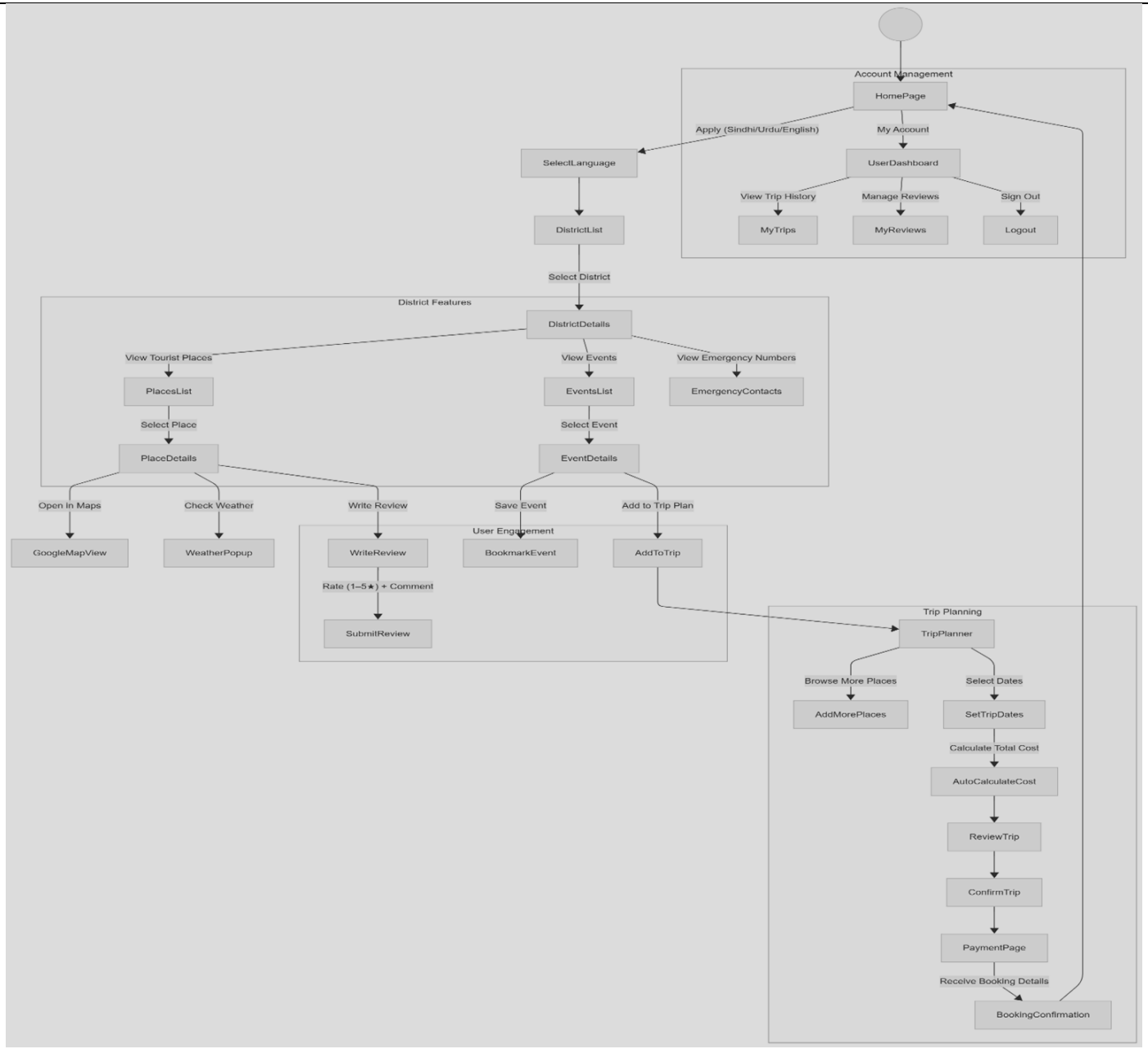

Figure 4. Activity diagram

Figure 3 indicates the relationship between the four major actors within the smart tourism system. Through the platform, tourists search places, view AI-generated trip suggestions, create travel packages, and post reviews. Agents facilitate the system by handling bookings and assisting users where necessary. Hotel owners can provide accommodation and update their status and availability. The admin has control over overseeing the entire platform by managing users, tour packages, content translations, and system-level reports. These functions together constitute the complete working process of the tourism application [14].

The workflow activity diagram is shown in Figure 4. It begins with the language choice and browsing of the district, followed by access to essential functionalities such as tourist attraction sites, events, emergency contacts, and the information page. Users are able to open places on Google Maps, view weather reports, leave reviews, and add or bookmark events or places in a trip plan. The account management flow, which includes account login, trip history, and review management, is also represented in the diagram. The trip planning section illustrates how users select the date of travel, add additional places, determine their cost, and finalize the reservation. Overall, the diagram demonstrates the flow of a user through the application—from basic check-in to completing trip planning and booking processes—with each element of the system interconnected to ensure a smooth tourism experience.

Results and Testing:

Results:

Figure 5. Home Page

Figure 5 presents the Homepage design with a hero banner that displays the Thar Desert with a sunset landscape, 255,000 registered tourists, 158 hotels and resorts, 49 destinations, and 300 sunny days in a year. The interface comprises primary navigation and call-to-action features.

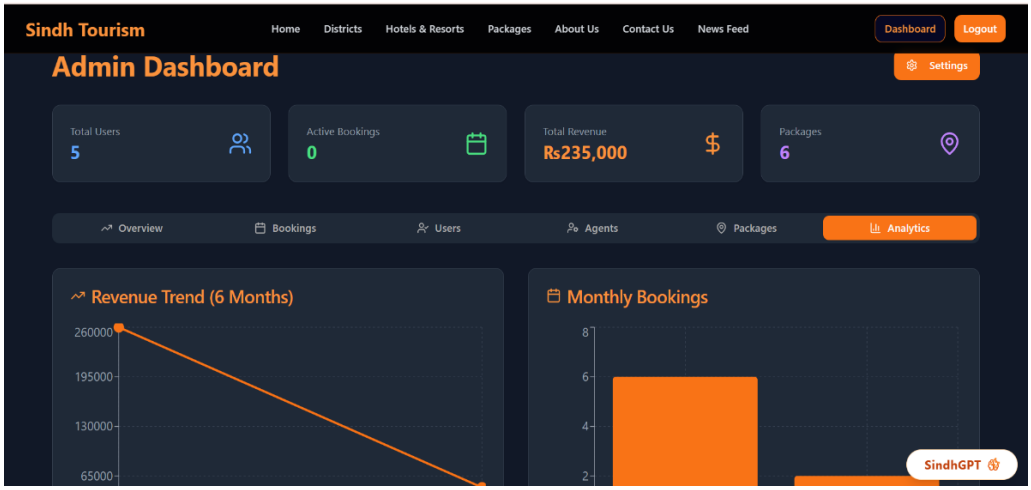

Figure 6. Admin Dashboard

Figure 6 is the representation of the admin panel that gives a clear view of the main metrics of the system, such as the number of users, active bookings, total revenue, and available packages. The dashboard format assists administrators in tracking activity quickly with the help of charts like revenue trends and monthly bookings. It also has quick navigation bars for booking management, user management, agent management, and package management. The layout makes the interface easy to use and well-structured, allowing administrators to manage operations efficiently.

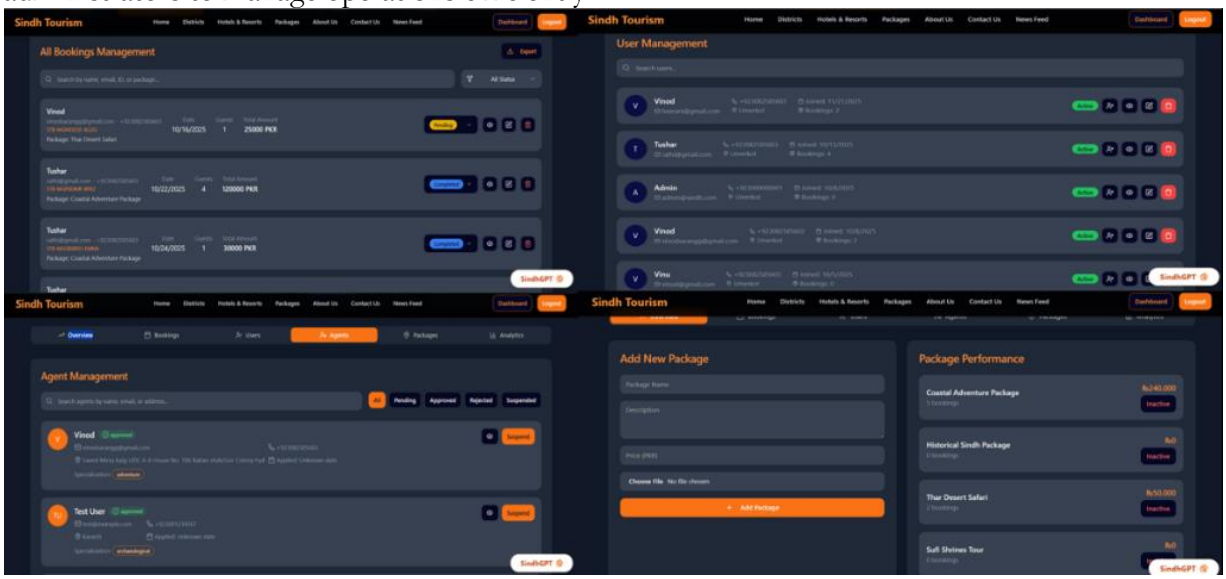

Figure 7. Admin Features

Figure 7 displays the administration options with a dark-themed, user-friendly interface. The Bookings Management section provides all bookings with status labels and action buttons. The User Management panel displays users with information such as email, date of joining, and number of bookings, along with controls for editing, deleting, and changing status. The Agent Management page allows admins to monitor and manage agents using status filters, such as Pending, Approved, Rejected, and Suspended. The Add New Package form enables admins to add new tourism packages by providing the name, description, price, and uploading images. relevant files. Lastly, the Package Performance panel shows active and inactive packages along with the number of reservations and corresponding revenue. The interface is consistent with the top navigation menu and prominent action buttons, allowing efficient administration and operations.

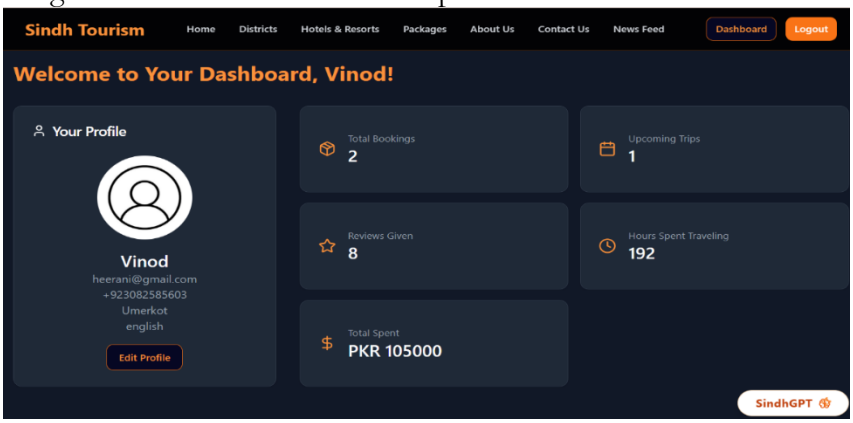

Figure 8. User Dashboard

Figure 8 provides a user dashboard that allows travelers to have their own account where they can monitor their activities and account details. It displays important information, including overall bookings, upcoming trips, and the number of reviews they have submitted.

It also shows the total hours users have spent on their routes and the amount of money they have spent on various journeys. The profile card presents their basic information with a hassle-free method for updating it. The design ensures that everything is simple and easy to read, allowing users to manage their travel history and plan future trips without difficulty.

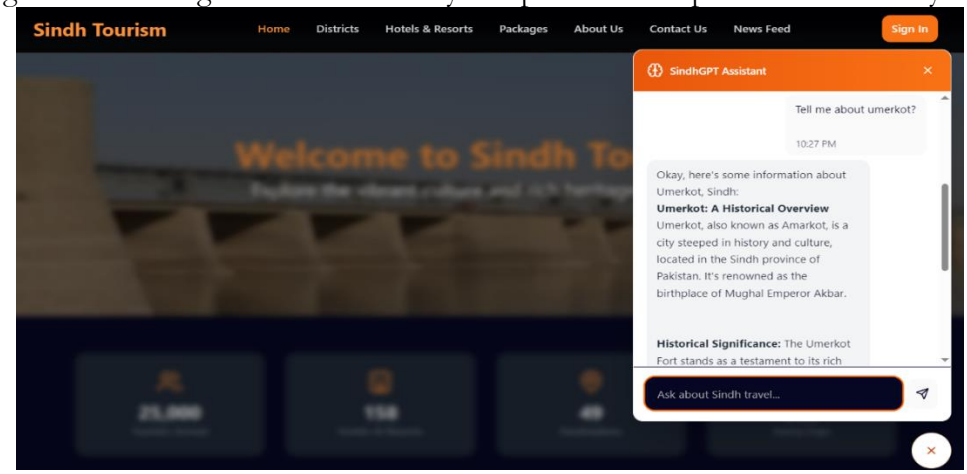

Figure 9. SindhGPT Chatbot

Figure 9 displays the SindhGPT Assistant, which is directly embedded on the homepage and provides immediate access to AI-powered travel guidance. The chat window is positioned conveniently on the right side, allowing visitors to ask questions regarding districts, history, culture, routes, and planning. In the example presented, the assistant provides an informative and organized description of UmerKot and can deliver useful, context-sensitive answers. The interface maintains readability of the conversation with a well-defined design and smooth scrolling. functionality. The experience resembles communication with an intelligent virtual guide, as users can enter their queries directly into the input field. This feature enhances the site by offering users personalized support and quick access to information without the need to browse through numerous pages.

Testing:

Tourist Survey Analysis:

Table 1. Tourist Survey

Challenge	Respondents	Percentage
Difficulty accessing accurate information	98	65
Planning optimal travel routes	87	58
Lack of personalized recommendations	108	72
Language barriers	65	43

Table 1 indicates that several common challenges faced by tourists in Sindh exist. A significant percentage of respondents cited difficulties in obtaining accurate information and a desire for more personalized guidance when planning their travels. Route planning also emerged as a considerable challenge for most participants, and inconveniences were further exacerbated by language barriers. These results highlight the need for a comprehensive, user-friendly system that can provide support to travelers throughout their entire journey.

System Usability Testing:

Table 2. System Usability Testing

Feature Tested	Easy	Average	Difficult	Satisfaction
Viewing Attractions	25	4	1	83 percent
Personalized Itinerary	24	5	1	82 percent
GIS Navigation	26	3	1	87 percent
Offline Access (PWA)	27	2	1	90 percent

Table 2 provides the results of the usability testing, showing that users found most features easy to navigate, especially GIS-based navigation and offline access. Overall satisfaction scores were high, with offline access receiving the highest rating of 90 percent. Personalized itineraries and attraction viewing were also highly appreciated, indicating a generally smooth and user-friendly experience. The system demonstrated strong performance across all assessed functionalities.

AI Recommendation Performance:

Table 3. AI Recommendation

Test Case	Predicted Match	Accuracy
Solo Travel	7 out of 8	88 percent
Family Trip	10 out of 12	83 percent
Heritage Tour	6 out of 7	86 percent
Adventure and Nature	11 out of 12	92 percent

Table 3 shows the performance of the AI recommendation system, which had strong accuracy in various travel situations. The highest accuracy was also achieved by adventure and nature-oriented trips at 92 percent, followed by the solo and heritage travel types. Recommendations for family trips also showed a good performance. These outcomes indicate that the AI model is a reliable tool for understanding user preferences and offering relevant travel experiences.

Overall Platform Impact:

The platform generates a high sense of improvement in how tourists navigate through Sindh, making navigation more reliable and information more easily accessible. Based on the survey responses (n=150), major challenges such as difficulty accessing accurate information (65 percent) and lack of personalized recommendations (72 percent) were directly addressed through integrated advisory and navigation features. Users are able to locate both popular and less popular locations, such as Makli Necropolis and Ranikot Fort, without difficulty in finding reliable and structured information.

Combining artificial intelligence, geographic information systems, and progressive web application technology enables structured real-time decision-making for travelers while simultaneously providing offline access in areas with limited connectivity. The usability testing results, with satisfaction levels ranging from 82 percent to 90 percent across key features, indicate that the system improves user interaction and accessibility.

Moreover, the tools enhance deeper cultural engagement by highlighting local history, festivals, and heritage sites through interactive approaches and multilingual assistance. Overall, the system creates a smooth, informative experience that supports visitors throughout their journey while contributing to digital transformation within the regional tourism ecosystem.

Conclusion:

This paper introduces a smart tourism platform that aims to make the overall travel experience in Sindh more effective and accessible, ensuring that the major issues encountered by tourists, such as inaccessibility to credible information, navigation challenges, lack of personalized guidance, and linguistic barriers, are appropriately addressed. The platform combines a rule-based AI recommendation system, Web-GIS mapping, multilingual support, and PWA technologies, thus facilitating offline usage and interactive exploration of cultural and historical locations.

The evaluation results, including chatbot accuracy of 92 percent and usability satisfaction levels above 80 percent across major features, demonstrate that the system effectively meets identified user needs. The survey findings confirm that the proposed solution directly responds to the dominant challenges highlighted by participants.

However, the system currently operates within a rule-based recommendation framework and depends on available digital datasets, which may limit scalability and adaptive

learning capabilities. Future improvements may include machine learning-based recommendation enhancement, expanded multilingual NLP support, cloud-based deployment for scalability, and integration of advanced features such as augmented reality for immersive cultural interaction.

Overall, this paper demonstrates that the structured integration of intelligent technologies can strengthen the tourism ecosystem in Sindh, support cultural heritage preservation, enhance visitor satisfaction, and contribute toward sustainable economic development.

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